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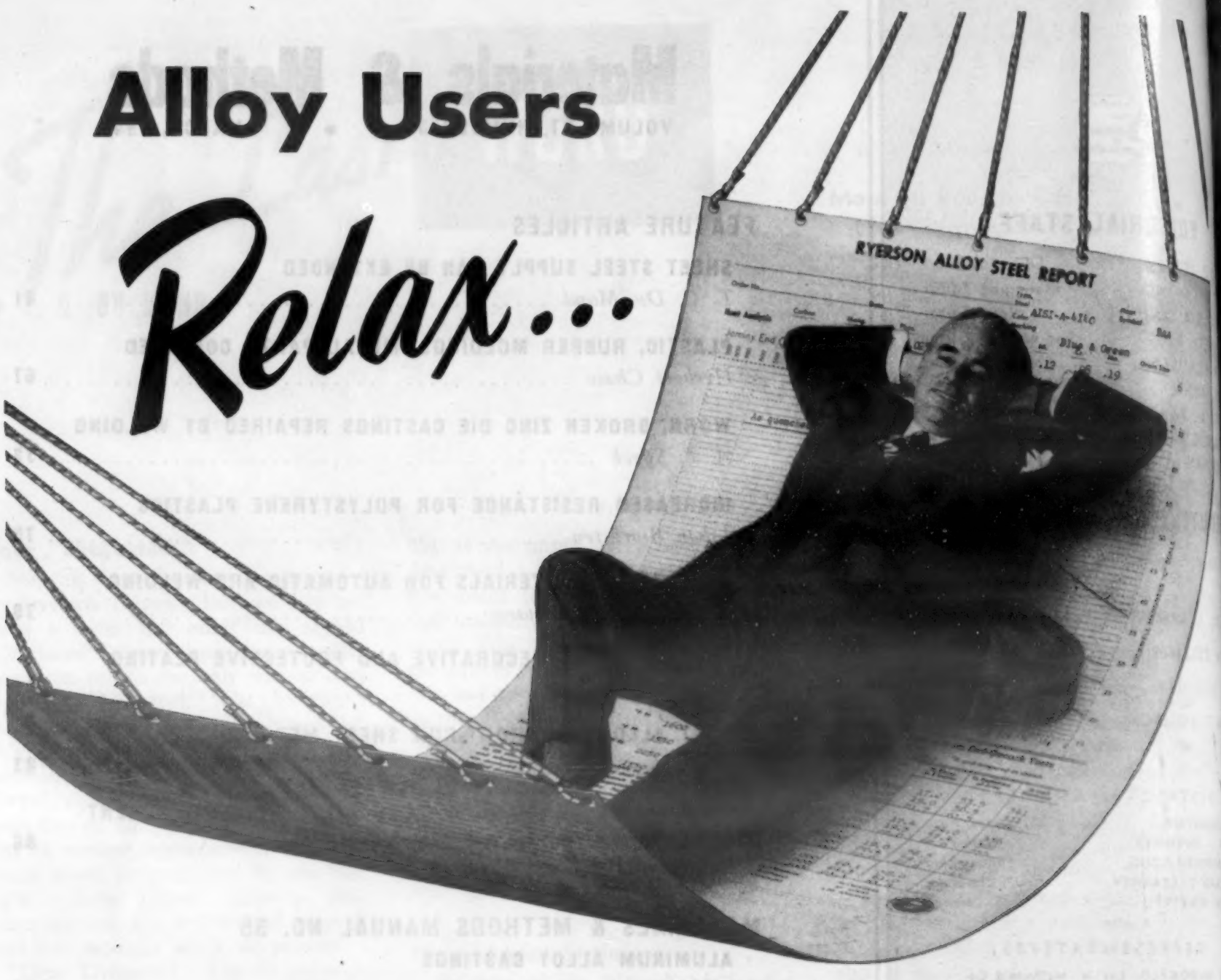
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RYERSON STEEL

The MATERIALS OUTLOOK...

COMMODITIES AND MATERIALS RELATED—With a fall in the market price of grains and commodities, a fall in the price of raw materials is expected. Two reasons are cited. First, it is felt that domestic ores of many kinds rose in price with agricultural products by sympathetic action. Second, world production of metals is rising and Congress is expected to encourage higher imports. While some price adjustment is expected, prewar levels are not anticipated by a long shot.

SYNTHETIC RUBBER CAPACITY AMPLE—Before economists completed their report advocating that Congress force the use of synthetic rubber on industry, the problem began to solve itself. Synthetic rubber capacity was to be kept high as a defense measure. Actual use today is higher than the level sought by the economists. Improvements in the properties and in compounding have created a demand for so-called synthetics in mechanical products despite prices higher than for natural rubber. These materials will find increased use where high elasticity is not the prime requirement. GR-S rubber has been rather hard to get because some plants were closed, but the capacity is ample to meet supply needs for a considerable time.

ASBESTOS SUPPLIES TIGHT—Mechanical parts using materials largely or partially of asbestos will probably be hard to get all year. Spinning fibers have been hard to get in the quantities needed to meet a capacity demand for brake linings and asbestos textiles. The reason: South African production has fallen below wartime levels and pressure to meet expanding building requirements has diverted considerable good fiber.

METALLIC TITANIUM NOT WIDELY AVAILABLE—Although industry is becoming more interested in titanium metal, all that is being produced is allocated to the military. However, industry can get small amounts from the government plant for experimental purposes. There is plenty of ore, but efforts are directed toward obtaining oxide for paint pigment. One company has a process by which metal can be obtained ahead of the oxide, but is not using it. The metal is considered to have great possibilities as an intermediate between steel and the light alloys.

LEAD SUPPLY IMPROVING—Despite heavy usage of lead in pigments and gasoline, the supply for other industrial uses should be ample. The 1947 domestic mine production was 12% higher than in 1946. The former OPA price of 6.5¢ was too low for either domestic or foreign lead. Likewise, the present price of 15¢ is too high and not expected to hold. Future demands for lead are to be influenced by increased titanium oxide capacity and by extension in use of non-lead alkaline storage batteries.

THE COPPER SITUATION—Many experts feel that whatever copper shortage now exists is temporary in nature. Germany stripped Europe of copper, but Chilean exports to France and other European countries has increased, and our exports to those countries have been high. Europe does not use copper as extensively as we, so the situation there is expected to change rapidly. In the United States, aluminum has taken over many of the duties of copper. An improvement in the aluminum sheet and wire picture will probably ease the demand for copper even more.

BERYLLIUM-COPPER ALLOYS EASY—Beryl ores are now being imported in quantities sufficient to meet all visible industrial demands and still leave some surplus ore for stockpiling. Manufacturing capacity

(Continued on page 4)

The Materials Outlook *(Continued)*

is ample and, if the copper is available, there should be no difficulty with the supply of beryllium-copper alloys. Newer alloys are using somewhat less beryllium.

TUNGSTEN PLATING COMING—The Bureau of Standards, which has been active in plating research, announces a process for tungsten plating. Tungsten plating is said to rival chromium plating in hardness. The process produces an iron-tungsten plate with hardness values up to 900 Vickers. A cobalt-tungsten plate has the advantage over chromium of retaining hardness at red heat. Tungsten is in good supply.

USE OF BETTER STEELS INCREASING—While steel companies producing steels of the high-strength type are pushing their use as replacements for low carbon steels, some enterprising materials men are finding new and unthought of applications. By converting at least part of their sheet steel tonnage from carbon to the low-alloy steels, users are getting from 25 to 33% more products from a given tonnage. This has the effect of increasing tonnages. Most of the conversions are expected to be permanent in nature, since the better grades of steel are usually found to be more uniform in quality, therefore easier and cheaper to fabricate and finish.

ALLOYING ELEMENTS—Thus far little if any of the steel shortage can be attributed to the lack of alloying elements. Chromium, which has often been reported as scarce, is in good supply and prospects are that this will continue. Russian-controlled ores should be coming to us in increased quantities. The fact that chromic acid for plating purposes has been difficult to get at times has led to the impression that chrome itself was lacking. The fault lies in the lack of capacity for manufacturing the chemicals.

PLASTICS CAPACITY GROWING—According to authoritative reports, 1948 expansion will enable the plastics industry to produce at least twice as much as in 1946, the former peak year. Estimated industrial uses for 1948 are as follows: Automotive, 50,000,000 lb.; refrigerator, 32,000,000 lb.; radio, 12,000,000 lb.; aircraft, 15,000,000 lb. During 1947 production in vinyls and polystyrene increased more than did that of other plastics. Recent price reductions have made the latter material 60% lower in price than it was in 1942.

INDUSTRIAL DIAMOND PRICES—There is no shortage of industrial diamonds. Present high prices are due to the actions of the London-Amsterdam monopoly in trying to jockey the highest possible prices out of the United States Government, who has been in the market for stockpile purchases. Diamond stocks in the Netherlands have been accumulating. The Diamond Bureau, controlling at least 70% of the world's industrial diamond supply, is reported against permitting stocks to be built up in this country. We could break the various Dutch world trade monopolies by withholding aid until they came to terms, but there is no present tendency to do that.

MORE CONTROLS ON METALS?—Many in the metals industry believe that if the Marshall plan is adopted—as it now appears will be the case—the government will again take over control of distribution of tin, lead, antimony and cadmium. Moreover, the agitation on the part of Washington to "roll back" steel prices may cause producers of major nonferrous metals to take unusual caution to prevent prices of such metals from rising, lest they, too, come under government pressure. Even now "voluntary" controls are being attempted in steel to assure ample supplies for the freight car building program.

ZIRCONIUM VERSUS TANTALUM—Zirconium has much the same properties as tantalum except for melting point and density. Corrosion resistance is about the same except that zirconium has greater resistance to alkalies. The great potential supply of zirconium makes it possible to produce for much less than the present price of tantalum; hence will probably be adopted for many uses such as radio tubes, rectifiers, electrolytic condensers and parts in contact with acids. Zirconium has excellent ability as a "getter" in radio tubes.

Sheet Steel Supply Can Be Extended by Better Materials Engineering

by T. C. DU MOND, Managing Editor, Materials & Methods

WOULD YOU LIKE 25 to 30% more sheet and strip steel?

The chances are better than even that you can get the same result by using a different grade of steel which will enable you to make 25 to 33% more products from the same tonnage of steel you are now getting. It's not just a matter of changing your steel order, for you may have to re-engineer your product to get the advantages inherent in the better grades of steel.

We're assuming now that you have investigated materials other than steel and find that you must have steel and nothing else. For some time after the war aluminum looked as though it might be the answer to the problem. In fact, it was the answer in so many cases that the supply situation in sheet aluminum rivals that of sheet steel. In neither the

At least half of the industries plagued by a shortage of sheet and strip steel can help ease their own problems by taking advantage of better grades of steels.

case of steel or aluminum are supplies expected to be ample for some time to come.

Before we delve into the magic process whereby your plant goes from a starvation diet of materials to one which is almost normal, let's see why the steel shortage exists.

Most, but not all, of our present condition can be blamed on the war. The war can be credited with damming up a terrific demand for all types of consumer goods, most of which involve the use of steel; the war prevented normal replacement of industrial capital goods, largely built of steel; and, the steel mills themselves were called upon to extend their plate rolling capacity at the expense of sheet and strip capacity.

Although sheet rolling capacity has been increased since the war's end, this added capacity has not approached the increased demand for the products of the rolling mills. Each year sees an increase in the per capita use of steel. For a period of about 8 years there was no possibility of adjusting steel production to meet the constantly rising "normal" demand. As an example, we can take the automobile. Ten years ago the bumpers on the moderate priced automobile averaged about 50 lb. per set. Today bumpers average over 100 lb. per car. (Figures recently published claim that there is 14,500 lb. of steel in use in the United States for every man, woman and child in the country, as compared to 3,300 lb. per capita in 1900.)

While the steel industry, as a unit, is increasing its capacity, it is doing so with a degree of caution. Much of the scarcity is recognized as "temporary," although estimates of how long the temporary situation will exist vary widely. Too, steel management remembers the past history of the industry which has a regular feast or famine pattern. They are afraid that when the present feast is over the pickings will be rather lean. For this reason it is undesirable from the industry's standpoint to over-build now only to have future operating costs high through taxes and maintenance on idle units.

Another factor, usually overlooked in shouting for extra steel capacity, is that most steel companies are faced with a possible relocation of plants in the near future due to a coming reliance on foreign ores. It would seem to be foolish to build expensive capacity now only to have to abandon it before the investment could be recovered.

Interesting as all this may be, it has little effect on your problem today, namely, getting more steel, or pushing out enough products to meet the demand of your customers.

Three Choices Offered

Three things can be done to extend steel supplies.

First, capacity can be increased greatly as some people urge. This is costly, requiring an investment of $200 to $300 per ton of increased capacity; and slow, requiring two to three years or more; and, it will require several million tons of steel to provide equipment for the capacity, helping to increase severity of the present shortages.

Second, we can push all our equipment from blast furnaces and open hearths on down by overworking present capacity. This method is being used, but it is dangerous, for sooner or later the equipment is going to require shutting down for servicing and replacement of worn parts.

Finally, we can take advantage of the technological advances made in materials and select those materials which are best for the job. This brings us to the use of high-strength, low-alloy steels which can be produced on the same equipment as carbon steel and which can go far towards easing the present scarcity of sheet and strip.

Every day, more and more companies are realizing the value of the so-called high-strength, low-alloy steels. After being kept under wraps for several years, these steels are now coming into their own. Because of their strength characteristics, and excellent corrosion and abrasion resistance, these steels can generally be used in thinner sections than would be required when using ordinary carbon steels. Average weight savings on typical products range from 25 to 33%. From that fact, it is evident that by using the better steels, one ton can result in the production of up to ⅓ more goods than low carbon steel.

From the standpoint of the steel industry, an increase in demand for the high-strength steel can be handled without additional equipment and with practically no change in existing equipment. As a matter of fact, many companies may be forced to investigate the high-strength steels, since steel companies are trying to shift as much carbon steel demand into the high-strength category as is possible. All of the major steel companies have high-strength steels, generally sold under a trade name.

What would be the effect if every user of sheet and strip steel, that could logically do so, would change from ordinary to high-strength steels? It would have the same effect as would the addition of more than 3,000,000 tons rolling capacity. How do we arrive at this 3,000,000-plus figure? It is estimated that the area in which the steel shortage is most acute involves a present output of somewhat over 25,000,000 tons. It is further estimated that one-half the uses to which this output are applied could be met soundly and economically by the high-strength steels. If the 12,000,000 tons thus converted resulted in a minimum increase in product output of 25% we have what is, in effect, an increase in capacity of 3,000,000 tons.

An example of how this would work is the freight car production program which now calls for 10,000 cars a month. Based on the proportion of different types of cars built during 1947, between 13 and 14 tons of carbon steel will be required for each car.



High-strength steels fabricate as readily as mild steel and sometimes better, since quality is more uniform. Here bolsters are being arc-welded.

Of the 14 tons, 10 tons could be replaced by high-strength steel. This would give a net saving of 25,000 tons per month, or 300,000 tons a year. In this case, not all of the replacement would be in sheet and strip, but a substantial tonnage would be saved in the tonnage of these forms of steel alone.

Twelve year's experience on a freight car on which the weight was reduced by 13,000 lb. by use of high-strength steel shows that tremendous savings can be made in the operation of transportation equipment. On the car referred to, high-strength material cost $70 more than usual steel, but in the first year $162 was realized in increased operating efficiency.

Since it is well known that high-strength steels cost more than ordinary steels, the question of costs naturally arise. The better steel's base price on the average is 1.5 times as much as common steels. Extras are identical. Part of the increased cost is offset by more goods coming from an equal tonnage of steel. Other savings come from lower freight costs, lower fabrication and finishing costs, and, finally, a product of better quality results. Again in the case of a freight car, if a high-strength car were to be built in Chicago, the material cost for the light weight car would be only $72 higher than for ordinary steel. If the steel were shipped from Chicago to the West Coast, the difference in material cost would be narrowed to $16 because of freight savings.

Case studies, several of which will be cited, actually show that the end product is often cheaper in cost and higher in quality when carbon steel is replaced by high-strength steel.

Use Must Be Sound

No advantage will come to anyone if blind substitutions are made in applying high-strength steel. It cannot be substituted pound-for-pound, since this would just be throwing money away and actually wasting material.

There is much talk of a vast increase in pipe lines of all types in this country, and even though much



Any transportation equipment such as railroad cars, truck bodies, buses or trolleys can save operating costs and increase revenue loads by taking advantage of high-strength steels. (Courtesy: Bethlehem Steel Co.)

steel will be used, high-strength steel is not considered to have any advantage over ordinary carbon steels. Thus, no attempt will be made to convert steels here. Although high-strength steel is highly resistant to atmospheric corrosion, it does not appear to offer much advantage in fighting the wide variety of corrosion types found in the earth.

In some segments of the automotive industry today, high-strength steels are being used simply because this type of steel is sometimes available when carbon steel is not. Such use is considered unsound, not only because the cost is too high, but because material is actually wasted.

No one can say just how much time it will take to re-engineer a product to use high-strength steel. It all depends upon the product. The same element of doubt holds true in adopting manufacturing processes, but in most plants the change-over can be effected without difficulty. One shop reported that it had less trouble working with high-strength steel because of its uniform quality with the result that output per man actually increased. An example, too, is that fusion welding time is reduced because of the reduced thickness of section.

Where Can High-Strength Steel Be Used?

The possible places where high-strength steels can be used have not all been determined, but several good examples can be cited to show the results others have attained. Steel companies, through their field engineers, are urging all of their carbon steel customers to examine all of their uses to determine where sound replacements can be made.

One steel company in outlining its plan to push the use of high-strength steels suggests that high-strength steels should be used where they can accomplish any one or more of the following:

Reduce weight of the product
Increase payload
Provide longer life
Result in more economical operation
Give greater strength
Lower maintenance costs
Lower freight charges on shipments of finished goods.

If the application would appear to be temporary, then it cannot be considered to be a good one.

In direct substitutions of most high-strength steels for carbon steel, weight reductions of from 31 to 36% are necessary if material costs are to be equal. However, redesign of the product can often more than offset the price differential if any should remain.

Here are representative automobile parts being made out of high-strength steel: muffler shells, fenders, bumper guards, deck lids, bumpers and hoods. There are many more parts, but these examples will serve to illustrate the point.

From the standpoint of helping circumvent the steel shortage, sheet and strip thicker than 14 gage represents the best area of use. Approximately 0.071 in. is the minimum thickness in hot-rolled high-strength steel. Below that thickness cold reduction is necessary and cold-reduction capacity definitely is limited.

Now let's see how sound materials engineering has helped some resourceful manufacturers:

Refrigerators

In making refrigerator bodies, a certain manufacturer formerly used 220 tons of carbon steel to produce 12,000 wrap-around sheets (the body of the box). He now produces the same number from 160 tons, an immediate saving of 60 tons. Because of the higher strength of the better steel an expensive and complicated door frame was eliminated being replaced by a simple bracket, thus saving additional material. Plus values were a saving of 30 cents per box on finishing costs, better welds and longer service life. One item the manufacturer did not count on at the outset was a substantial lowering of freight costs in moving his products into the principal marketing areas.

Switch Boxes

Another company uses about 500 tons per month of high-strength low-alloy steel strip in the manufacture of switch and conduit boxes. The company estimates a saving of about $3,500 per month on freight on their finished products. When asked if the use of this steel was only a temporary expedient to get more material, a spokesman replied: "We think this can be analyzed better by asking if we would like to save from $3,000 to $5,000 per month on freight during times when the money would mean more than it now does."

Gas Cylinders

Several companies making and using liquefied gas cylinders report savings in manufacturing and using the tanks and decided favorable reaction on the part of handlers when the tanks were made of high strength steel. In one case 0.079-in. high-strength steel replaced 0.130-in. carbon sheets with a saving of 20 lb. per cylinder. In one year's normal handling the reduced weight saved 98¢ in freight charges—33¢ more than the extra cost of steel.

Another states that 500 tons of high-strength steel were sufficient to make 10,000 propane cylinders, but that only 7,500 could be made from the same quantity of carbon steel sheet. All costs, including reduced freight to their first destination, show a saving of 31¢ per cylinder.

Power Shovels

One power shovel maker uses high-strength steel in crane booms with a resultant saving of 13% in dead weight of the boom. This proves a decided operating advantage since it increases the crane's lifting capacity. With the lighter booms, machine rotation is speeded up, there is less weight to swing, less load to start and stop. All these features make for faster operation.

Other Applications

A maker of cement-lined hot water tanks uses 0.082 and 0.062-in. high-strength steel sheets in place of carbon copper sheets in the shells. Thickness of steel could be reduced by 25 to 30%, thus getting more tanks per ton of steel.

In a gasoline tank truck and trailer, light weight construction saved 1,671 lb.—the equivalent of 287 extra gallons of gasoline handled on every trip of the vehicle.

A manufacturer of concrete mixers has replaced 8, 10 and 12 gage carbon steel sheets with 10, 12 and 14 gage high-strength steel sheets—a reduction of two gages in each case—with entirely satisfactory results.

Problems of Fabrication

In shifting from carbon steels to high-strength steels, some difficulties can be encountered if the shop man tries to handle the two steels alike. This is particularly true of drawing and forming. Because of their greater strength, the alloy steels require more force to produce a permanent set in sections of equal thickness.

Forming

The principal changes in cold forming practice for high-strength steel is in providing more liberal radius

of bends, slightly increasing die clearances and allowing for more spring back than with carbon steel. These changes are not hard to handle and once provided for can cause no difficulty.

Welding

All welding processes are readily applied to the high-strength steels, for joining these steels to each other or to ordinary steels. Welding methods most commonly used include metallic arc, submerged arc and spot welding. When welding is used in high-strength steel designs, weight savings can be increased over the nominal 25 to 33%.

Other Operations

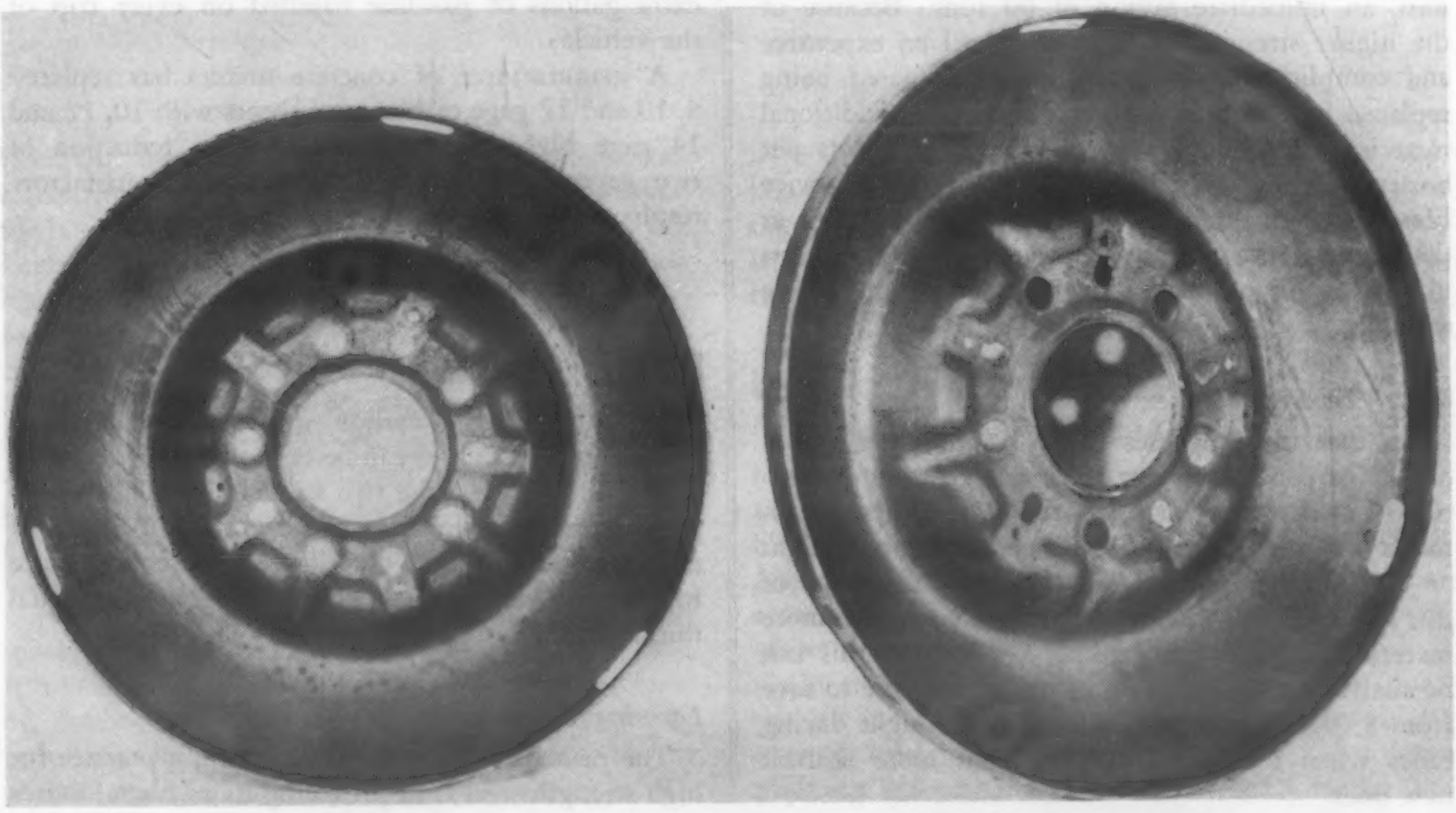
Standard practices generally can be followed in shearing, punching, reaming, sawing, milling and drilling operations on high-strength steels. In shearing and punching the parts should be more securely clamped than for ordinary steels. Likewise, in machining, it has been found that reduced cutting speeds result in increased tool life.

Names and Makers

There are about 10 different brands of the group of steels most commonly referred to when the term high-strength, low-alloy steels is used. Some of the names are Cor-Ten, Man-Ten, N-A-X High Tensile, Aldecor, Mayari-R, Yoloy, Otiscoloy, Hi-Steel, Dynalloy and Double Strength.

Companies most prominent in producing and offering this group of steels include, Carnegie-Illinois Steel Corp., Republic Steel Corp., Alan Wood Steel Co., Bethlehem Steel Co., Inland Steel Co., Great Lakes Steel Corp., Jones & Laughlin Steel Corp., and Youngstown Sheet & Tube Co.

The automotive industry is adopting high-strength steels for such uses as these passenger auto wheels. (Courtesy: Great Lakes Steel Corp.)



Combinations of conducting and dielectric properties are provided in electrical parts by judicious use of molded sections containing metallic inserts.

Plastic, Rubber Moldings and Metal Parts Combined to Advantage

by **HERBERT CHASE**

RELATIVELY FEW PLANTS undertake molding jobs so difficult or fulfill specifications so exacting as are undertaken and met regularly by the Scintilla Magneto Div. of Bendix Aviation Corp. at its Sidney, N. Y., plant. Although a large proportion of the moldings are for Scintilla's own products, chiefly for aircraft in which highest quality is essential, other work is done for customers whose specifications are exacting and who demand parts capable of exceptional performance.

Years of experience in meeting demands of increasing severity have changed the complexion of molding material, methods and equipment in many respects. At present, only thermosetting materials are used. Phenolics, once more extensively used, are still employed but in most magneto parts were displaced long ago by hard natural rubbers. The latter have given place entirely to hard synthetic rubbers and these synthetics are now preferred for much of the work to melamine resins, although the latter are still employed.

Although performance characteristics of the molded piece are paramount, molding characteristics have to be given attention because they, as well as other inherent properties of the materials, have important bearing upon what can be produced commercially as molded products.

In general, for example, a material that is easily transfer molded is favorable where inserts are not sturdy or may be displaced in compression molding. On the other hand, some jobs must be compression molded and some have to be molded at quite low pressures—much too low for certain plastics to be considered. Some types of molds make it essential to use a material that remains quite flexible in its molded form to permit ejection and some moldings have to remain flexible to meet service requirement.

Some materials are hard to mold and tend to crack, especially around inserts, when cooling but yield some marked advantages if these difficulties can be overcome. Curing time, tendency to vulcanize or to change in other respects before molding, need for special cold storage facilities before molding and for baking after molding and scores of other considerations have to be weighed in seeking the compromise that will yield optimum results.

At present, Buna S hard rubber is preferred for a large percentage of magneto and related applications, partly because of good resistance to arcing, excellent dielectric strength, and because moldings withstand about 50 F higher temperature in service than do natural rubbers. Buna N hard rubber is also used for some parts. Buna compounds are employed chiefly for parts that must be quite hard when molded. Molding is readily done, impact resistance is high and machinability is good.

All parts molded from these materials require baking from 15 to 20 hr. at 270 F after molding and, as shrinkage occurs during the bake, allowance for it must be made. Where close dimensions must be held, baking on a fixture is commonly necessary. Baking is done in electrically heated ovens, the temperature of which is controlled thermostatically. Ovens are equipped with fans for air circulation to keep the temperature uniform throughout the ovens.

Neoprenes are generally employed by Scintilla where a soft and flexible insulation is needed. Among the other properties, they afford good resistance to ozone, corona and other aging atmospheres, and good dielectric properties are considered important. At present only Buna, Neoprene, Bakelite and Durez are used by Scintilla. Some of these have to be stored

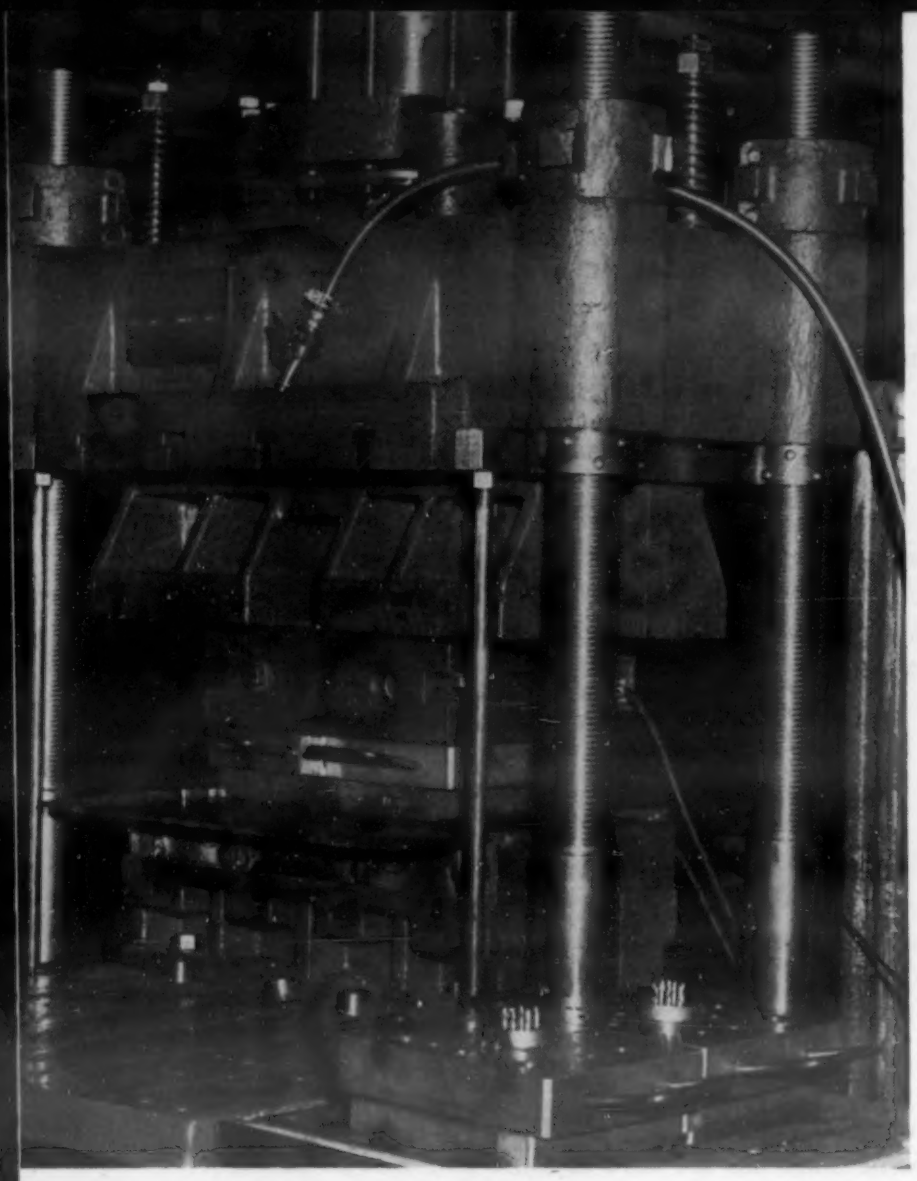


Fig. 1

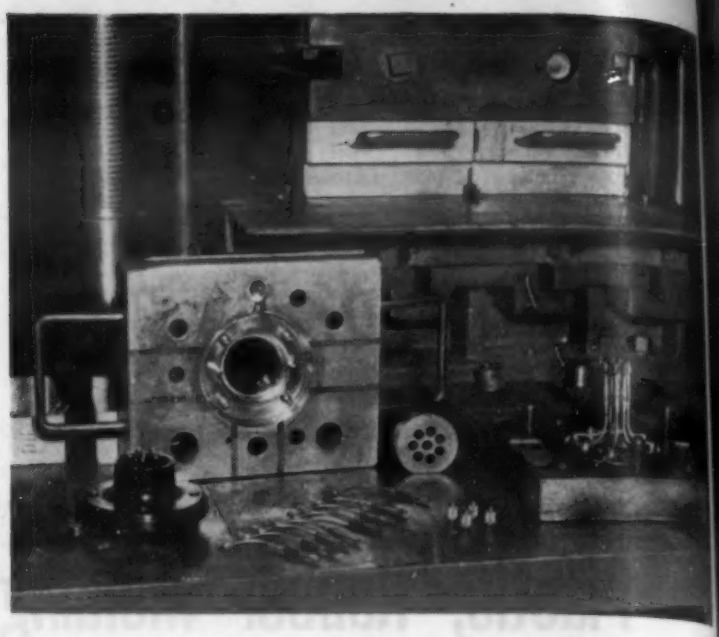


Fig. 2

at low temperatures, as vulcanizing occurs at room temperature if the exposure is long.

Although, partly to hold precise dimensions, molds are made with extreme care and in general are chromium plated and polished, and cooling or baking fixtures are used where needed, it is still necessary on many moldings to do considerable machine work to keep critical dimensions within specified close limits. Often the inserts also have to be machined in making other cuts, and in many cases, where the inserts project from the molding for holding purposes, the projecting part has to be cut off anyway. Many tools for machining moldings are provided adjacent to the molding department and, where these cannot do the jobs required, the parts are sent to other departments for machining.

Many scores of molds are available and are set up for use as needed to meet production schedules. Only a few molding operations, fairly typical of work done in this plant but each having its points of interest, are described here.

Among moldings made from Buna S is a distributor head for the ignition harness of the Pratt & Whitney Wasp Major aircraft engine. This is produced by transfer molding in a Stokes Standard press of the latest type equipped with a top cylinder for use only in transferring the charge. As no less than 12 inserts are required in this mold, and the molding cycle is fairly long, four separate duplicate molds are employed.

While two molds are curing in the press, the operator unloads moldings from the other pair, applies new sets of inserts to them and assembles the molds ready for placing in the press when the other pair is taken out. He also has time to weigh the charge, made up of squares cut from ⅜-in. sheet stock, and places the charge in a preheat oven in time to attain the desired temperature, 175 F, before the charge is loaded into the injection cylinder.

The oven as well as the press platens, the injection cylinder and the hot plate (next to press for keeping molds hot while not in use) are heated by electric resistance units. In fact, all heating in the molding department is done electrically, hence no steam piping to presses or ovens is required. In the press, heat is conducted to the molds from spacer blocks, the mold sections being quite thin and heat transfer rapid.

To prepare the mold, the four smaller inserts, which are tapped, are fastened to the mold's upper section by loose studs turned by a screwdriver from the top of the upper section. The lower section is then laid flat and the eight longer inserts are applied. Their lower ends fit holes in the mold's lower section and the upper ends are centered by holes in a plug which is set in place after the top section is assembled to the lower one. The plug also acts as a core that forms a recess into which the inserts, each to be surrounded by a wall of rubber, project.

As the press is opened, the transfer plunger is withdrawn with the "card" of flash at its end and the two molds removed are replaced by those in which inserts have been placed. This brings the sprue openings of the molds below corresponding openings in the transfer pot, which is built into the upper block. This pot is then filled with the preheated charge, the card clinging to the ram from the prior cycle having been pushed off. The operator then presses a button on the control panel and the press closes automatically applying, in this case, 120 tons to hold the molds closed.

When closed, the 3-in. injection ram is advanced and slowly forces the charge into the mold under a total pressure of 15 tons. Transfer requires about 1 min. and a 12-min. cure is allowed, after which



Fig. 3



Fig. 4

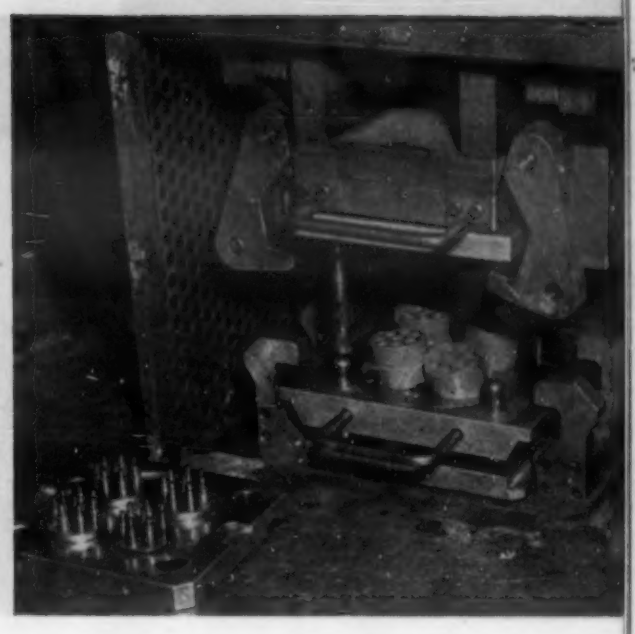


Fig. 5

In Fig. 1 molds that are being made ready are kept hot. A closeup of a distributor with inserts and mold sections can be seen in Fig. 2. Fig. 3 shows the set-up for producing a flat phenolic molding. Powder is emptied into the mold cavity to help support inserts. Plug grommets are produced from Neophrene as shown in Fig. 4, and then are stripped from the mold on the press, illustrated in Fig. 5.

the press opens automatically. With the four molds, about 7½ pieces per hr. are produced.

In order to facilitate and speed the removal of moldings, an air operated separating press is set next to the machine and is used for opening the mold after which the moldings can be lifted free. They are set on fixtures to hold critical dimensions when subsequent baking is done. This and other Stokes molding presses have their own pumping units and panels that automatically control all events of the cycle. Heating is controlled, however, by thermostatic elements at points adjacent to molds, as for all presses in the molding department.

In this as in many other jobs where precise insert positioning is important and inserts might be distorted or displaced, it is necessary to keep pressure applied to the plastic within bounds and to check moldings occasionally to see that inserts are not displaced or broken. This is done by placing a molding in a Norelco "Searchray" machine which has a fluorescent screen on which the X-ray image can be seen. If broken or displaced inserts are found, steps to avoid these faults are taken.

Among many phenolic moldings produced is one for a business machine built by a customer. Molding is done in the 75-ton Stokes press. This molding is rectangular, about ⅜ in. thick, and contains rather fragile brass and silver inserts. When set in place, the inserts are tapped lightly with an aluminum hammer to make sure that they seat properly but, as the inserts can be bent easily, the molding gave trouble in other shops because the plastic injected would deflect the inserts toward the bottom surface and then moldings would not pass breakdown tests.

This trouble has been overcome by a combination of transfer and compression molding. A small cup of powdered molding compound is poured into the mold, just before the mold is closed. The powder flows under the inserts and gives them support when, after the mold is closed, a preform of the same plastic is fluxed in the transfer pot and fills the remainder of the cavity, mixing and curing with the powder already in the mold. This job now runs on a 2-min. cycle and each molding removed is placed in a toggle fixture where it cools and is prevented from warping. Neither half of the mold has to be removed from the press, as the lower half, which remains fixed, has foot-operated kickout pins.

Recently developed by Scintilla is a line of waterproof connectors in which the dielectric elements, termed "grommets," are produced in multiple-cavity molds in several sizes, each molding having insert holes that are cored by pins fixed in the mold, the inserts being applied after molding. A set of one size of four moldings is shown at the left of an open die in a 15-ton Hannifin air operated press.

At the right of the press is the weighed charge cut from strips of Neoprene and preheated to 120 F. This charge is loaded into a pot; the plunger is then lowered into the pot transferring the charge or material into the mold. Heat is conducted to the mold from resistance heaters in platens above and below the mold, which is run at 330 F.

The mold is made in four sections, the two center ones containing the four cavities. In the bottom section there are core pins that run through into the cavity, and the top section has similar pins that extend from the top into the cavity and just clear the lower pins with which the upper ones are in line. This top section also contains the sprue hole through which the charge is injected as the press closes. After an 8-min. cure, the press opens, withdraws the transfer plunger with its card and breaks the sprue.

Then the mold is transferred to the air operated



Fig. 6

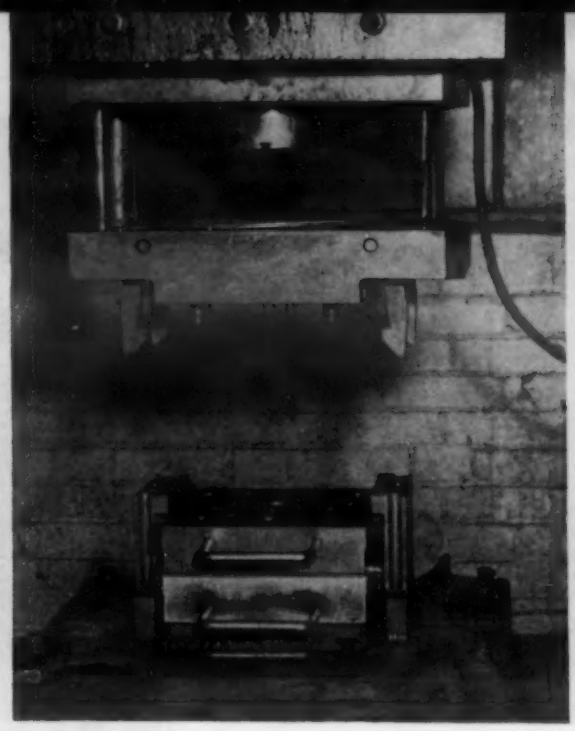


Fig. 7



Fig. 8

Fig. 9

stripper press, and the top plate is pulled off. This strips the molds from the top core pins. Then, while the bottom section is held by the press, the upper cavity section is lifted by the ram. This first strips the moldings off the lower pins and, when the lip of the lower cavity section strikes the stops, pulls the upper cavity section free. This frees the moldings from the cavities and they are lifted out.

An average of 15 moldings of this size (about 2 in. dia.) are produced per hr. The mold is reassembled in the stripper before returning it to the press. By changing stripper stops, the stripper is adapted to handle many different molds some of which are constantly run in adjacent presses.

Among several moldings still produced from Melamine resins is a coil housing. The plastic is a special arc-resistant type of Melmac that is preformed and is subjected to electronic preheating until softened, just before being placed in the transfer pot immediately above the cylindrical portion of the cavity.

Before transfer molding, in a 50-ton top-ram press, the mold receives three inserts. Screw plugs are applied with a screwdriver to the tapped inserts and, of course, have to be removed before the molding can be ejected. As one insert projects into the side of the major core, it is fitted into a dovetail slot and this dovetail then is closed by a mating filler block which slips out parallel to the core axis when the molding is ejected. This is necessary because, otherwise, the molding could not be ejected, as the insert would constitute an undercut.

The mold is made in three pieces, one of which carries the main core pin. Heating is by conduction from the lower platen and from the block which contains a transfer pot. As the mold closes, this plate comes to rest on the mold, which is heated to 330 F, and then the pot is filled with the electronically preheated preforms. Further motion of the press ram lowers the transfer plunger and transfers the charge into the mold.

After the 8-min. cure, the press is opened and the mold is shifted to a stripper press after removing insert holder plugs. Separation of the mold frees the molding. Many Melmac moldings are transferred after ejection into boxes of coarse sawdust with which the moldings are covered to insure slow cooling, as this has been found to reduce the tendency to crack around inserts. All Melmac moldings are baked 24 hr. at 200 F after having cooled to room temperature.

One advantage of the Oilgear presses employed for Melmac and for some other molding work is that the operator has full control of ram travel and the rate of this travel is readily adjusted to suit the plastic and mold being used. Each press has its own variable displacement pump and the operator can vary the displacement down to zero, thus changing the injection rate as needed.

Most transfer molding is done, as above described, from pots with plungers that transfer the full charge in one stroke, the pot then being refilled. The mold or molds remain in the press until moldings are sufficiently cured. A variation of the process, termed "gun molding," is employed in this plant with some synthetic hard rubbers and may be considered as midway between transfer and injection molding, although thermosetting plastics are used.

In gun molding, the heated cylinder is charged with a rod or bar of synthetic rubber having sufficient volume to fill several molds in succession without being recharged. The molds are locked mechanically, heated to 350 F, and then are filled by lowering into a conical opening the mating nozzle of the "gun" or charging cylinder. This cylinder is heated, for the Buna S compound employed, to 185 F, the charge first being preheated in an oven to 125 F. In the cylinder, which is supported from arms arranged to slide on the vertical tiebars of a press, is a ram to which hydraulic pressure is applied to force the compound into the mold.

When the mold is filled, ram pressure is released, the cylinder is raised, a tapered plug is forced into the mold opening and is locked by a wedge. Then the mold is slid into an oven, the floor of which is level with the press bed, and is left to cure 17 min. at 350 F, in the case of one molding.

Molds are locked by hinged links that have tapered



Fig. 9

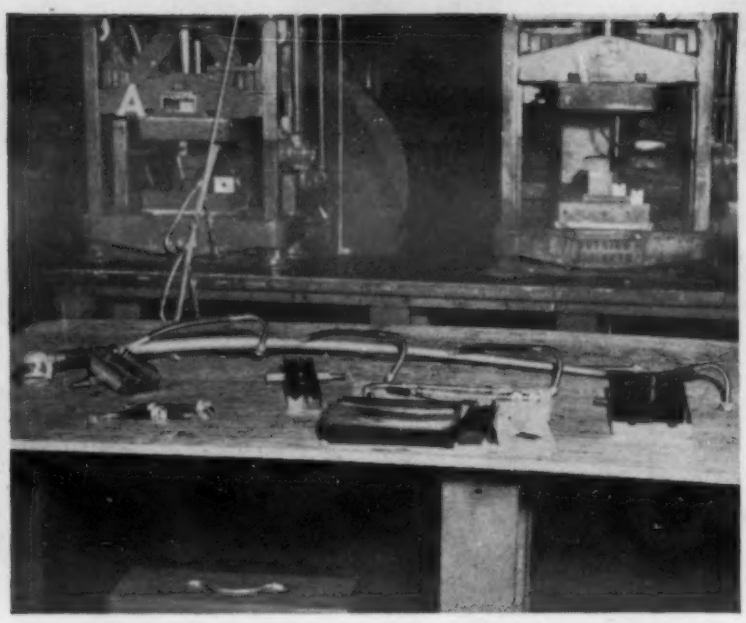


Fig. 10



Fig. 11

The plastic part in Fig. 6 contains three inserts, as shown, and is molded in the press in Fig. 7. A gun above the mold in Fig. 8 fills the mold with a Buna compound. In Fig. 9 a gun mold is opened to show a distributor head that it molds. A set of inserts, foreground, is molded in each head. Figs. 10 and 11 show steps in producing harness manifolds. Buna compound is molded around flexible metal base to form the completed unit.

surfaces to engage mating surfaces on the top portion of the mold when driven home. When curing is complete, the mold is withdrawn from the oven, the plug wedge and plug are removed, the links are knocked outward, and the mold sections are separated, freeing the molding. During the war, this type of molding was done in a conveyorized setup that carried molds through the oven on a timed schedule and returned them to the press bench as rapidly as the loading and unloading cycle could be performed.

For gun molding, the plastic must be one that will not cure so rapidly as to setup while in the cylinder but, with the hard rubber now used, this time is a 3-hr. maximum. The process is well adapted to some classes of moldings. Operation can be so arranged that there is no loss in the form of a "card" left in the cylinder at the end of the ram stroke. As now applied, four or five molds are usually filled before recharging the cylinder.

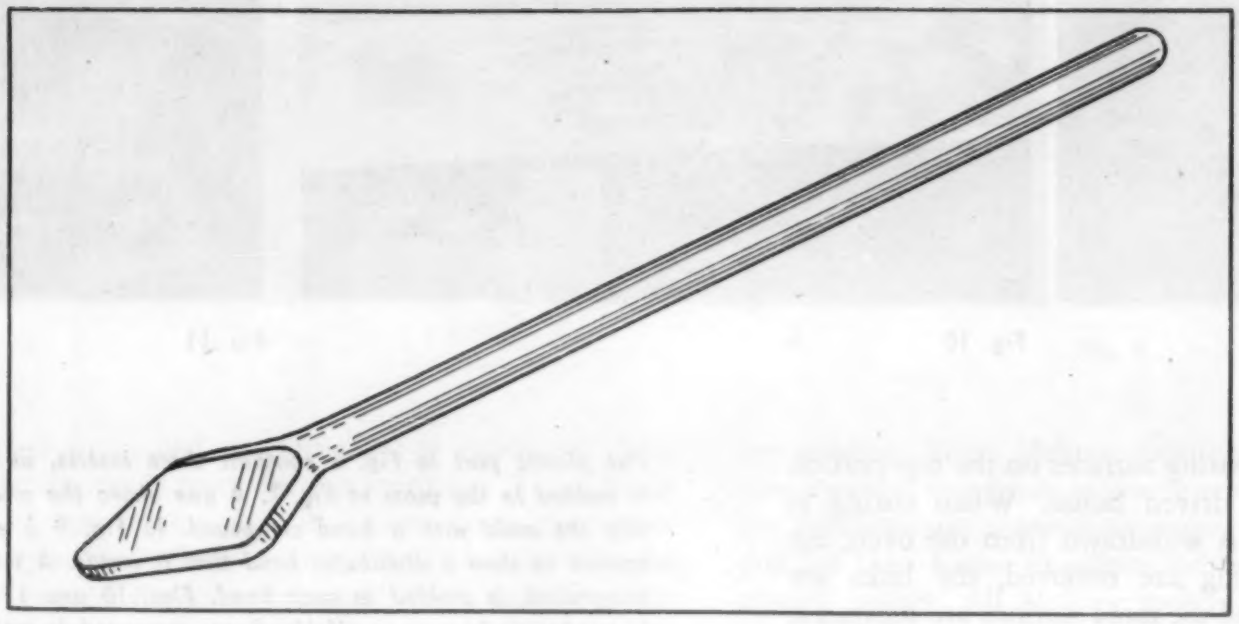
If the cycle is short or many molds are used in rotation, a helper assists the molder by handling and opening molds. Where some dimensions are critical, the molding is cooled in a fixture and is held on a similar fixture when subjected to subsequent baking.

Few jobs done in this plant are more unusual than that of applying Buna N soft rubber covering to the flexible metal tube and fittings that form branches of secondary harness radio shielding manifolds for Pratt & Whitney Wasp Major aircraft engines. The main solid tapered tube of these secondary shields joins the main cast circular ring shield at its large end and has eight branches made from spirally wound flexible tube covered with braided wire that receives the synthetic rubber covering. As the flexible metal lead is not designed to resist heavy external pressures and would be collapsed if heavy molding pressure were applied, molding is done at a pressure of only 800 psi. in 15-ton Hannifin air presses.

The flash molds used are merely pairs of blocks of steel, having grooves of semi-circular section along one side. An oblong piece of sheet Buna N 0.070-in. thick, cut to correct length and width to fit the tube surface, is laid in the groove of each half of the mold and the halves are then applied to each side of the tube. When one mold is in place, the lead is transferred to the press and the mold is closed between two heated platens. A hook attached to a rope with a counterweight at its opposite end is used to support the overhanging portion of the harness while curing proceeds for 20 min. at 310 F.

Each lead is covered in succession in this manner. Molds not in use are kept on the hot lower platen so that they remain hot until needed. At the end of the cure, the press is opened and the next lead is similarly treated. Each synthetic rubber tube thus molded fits against a shoulder of the end fitting, and must make a good bond with the metal there. Such a bond is insured by seeing that the metal is thoroughly cleaned with a solvent and is free of all oil or grease before molding starts. Only a light flash is formed at the mold parting and it is torn off by hand when the mold is opened. Then the parting line is cleared with a file. The result is a pressure tight covering of synthetic rubber that is highly oil-, heat- and abrasion-resistant around the metal tube.

Such are the methods and equipment used for jobs more or less typical of most of those performed. Although efforts are made to keep costs as moderate as satisfactory moldings permit, nothing is sacrificed to insure meeting exacting quality specifications. A large proportion of the moldings have to withstand electrical breakdown and other tests that could not be met unless all reasonable precautions in molding are taken.



A spatula similar to the one shown here is helpful for breaking down oxides during welding of zinc-base die castings. It can be formed from a bronze welding rod.

Worn and Broken Zinc Die Castings Can Be Repaired by Welding

by A. E. SPECK, Dominion Oxygen Co., Ltd.

Here is a tested method of salvaging zinc alloy die cast parts, by fusion welding, that can be successfully practiced in any shop.

IT IS OFTEN ADVANTAGEOUS to repair broken or worn zinc and zinc alloy die cast parts. They can be successfully repair welded by observing a few simple precautions. A brief description of the proper fusion-welding procedure is given here.

Too much emphasis cannot be put on the proper preparation of the parts to be welded. White-metal castings usually have either a hard oxide skin or a nickel or chromium plating. The white metal base melts at about 800 F, but the oxide and plating, if any, melts at about 2100 F. The first step, then, is to grind or file off the plating or the oxide coating for about 3/16 in. to ¼ in. on both sides of the fracture. To build up a worn or broken surface, clean and



A white metal bearing block being repaired by building up the broken out portion of the casting.

grind the surface; this will remove dirt, grease and oxides that might interfere with the welding.

Many easy jobs can be ruined unless the grinding is done properly. For while the oxide or plating is being melted the inner metal may become molten and the casting may finally burn up or collapse. Carburetor housings, for example, develop this oxide skin rapidly and they cannot be welded successfully unless the skin is thoroughly removed.

A spatula made from a piece of bronze welding rod, as shown in the figure, is useful to break down the oxides covering the fracture, to form the plastic metal, and to transmit heat from the flame to the metal when thin sections are welded.

An excellent welding rod can be made in the shop just before the welding operation. Use a blowpipe to melt a few scrap pieces of white-metal castings into a clean angle iron trough. Allow the molten metal to cool in air as a triangular-shaped welding rod. Many operators prefer this type of rod to the commercial white-metal welding rods. For ordinary work, rods should be 3/16 in. or less in dia. For small thin-walled castings ⅛-in. rod is recommended.

Keep parts well supported during welding to prevent sudden collapse of the heated metal. Carbon paste, rod, and plate, and wet asbestos paper are of great assistance in holding parts in position and furnishing the necessary support.

Choose a small blowpipe equipped with a small size welding head or tip. A slightly excess acetylene flame is recommended. However, some operators prefer a neutral flame. An oxidizing flame should not be used.

Welding Procedures

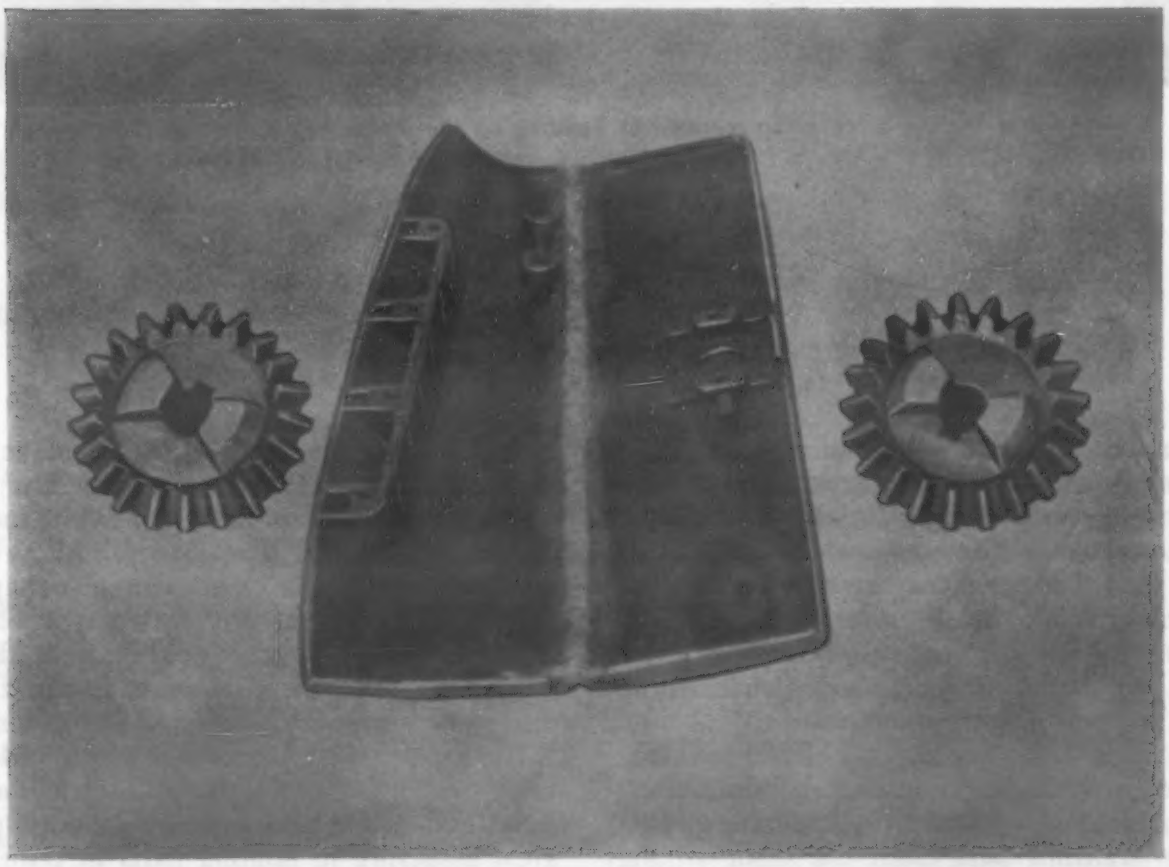
Broken parts can be welded, and worn surfaces can be rebuilt by using the following welding procedures. Before attempting to weld, preheat the entire casting to a temperature of about 250 F by playing the outer envelope of the flame over its surface. Every few moments hold the flame on the surface of the break for a few seconds and then continue to play the flame over the entire casting. The casting is ready to weld when fine beads or droplets appear on the surface of the break. If the casting is preheated evenly all over, these beads or droplets will appear over the entire casting at approximately the same time and there is danger that the casting will collapse

Maintain preheat during welding by occasionally sweeping the flame over the casting. Never bring the blowpipe tip closer than 3 in. from the casting at any time during the preheating or welding. When the casting is preheated, focus the flame on the fracture or the surface to be built up. Break down any oxides in the welding zone with the end of the welding rod or the spatula. To prevent collapse of the metal, add the welding rod a little at a time. By withdrawing the flame for short intervals you can keep the metal under easy control. Use the spatula to remove any impurities from the weld metal and to obtain complete penetration by puddling or stirring the molten metal. The spatula is also useful to smooth and shape the plastic metal and reduce the amount of finish grinding. Continue to build up the weld until it is from 1/16- to ⅛-in. higher than the adjacent surface. The surplus metal can be ground off when the weld has cooled. If appearance is important, the part can be replated after grinding and finishing.

To weld extremely thin sections, such as are encountered in carburetor float chambers, use the spatula or a piece of ordinary 3/16-in. bronze welding rod to transmit heat from the flame to the work. If the flame is focused directly onto the thin section, the metal may quickly collapse. To prevent this, after preheating the casting, direct the flame against the spatula about 1 in. above the end and touch the end of the spatula to the casting. Just enough heat is transmitted to melt the metal in the fracture.

During welding adequate ventilation must be provided so that the welding operator does not inhale any harmful fumes. Also, some die castings may spall when heat is applied, and, therefore, the operator's face, arms and hands must be protected against tiny flying pieces of white metal.

Before the welding operator actually tries to weld, he should practice on a worthless piece of white metal. He should try flame adjustments, preheating, manipulation of the welding rod, and use of the spatula, and he should note carefully the change in appearance as the white metal passes from cold to molten state.



Typical die cast parts salvaged by repair welding. The gears were machined after welding.

One of the least expensive plastics can be used in a number of difficult applications by using a surface material which is inexpensive and easy to apply.

New Treatment Increases Chemical and Abrasive Resistance of Polystyrene Plastics

by **JOHAN BJORKSTEN**, President, Bjorksten Research Laboratories

DISCOVERY OF A NEW TREATMENT for polystyrene makes possible utilization of this low cost transparent plastic in applications where previously it was necessary to use plastics costing many times more. The treatment overcomes the objections which kept the polystyrenes from many applications. Plastic moldings acceptable to industry for a variety of uses can now be made at a cost lower than metal stampings.

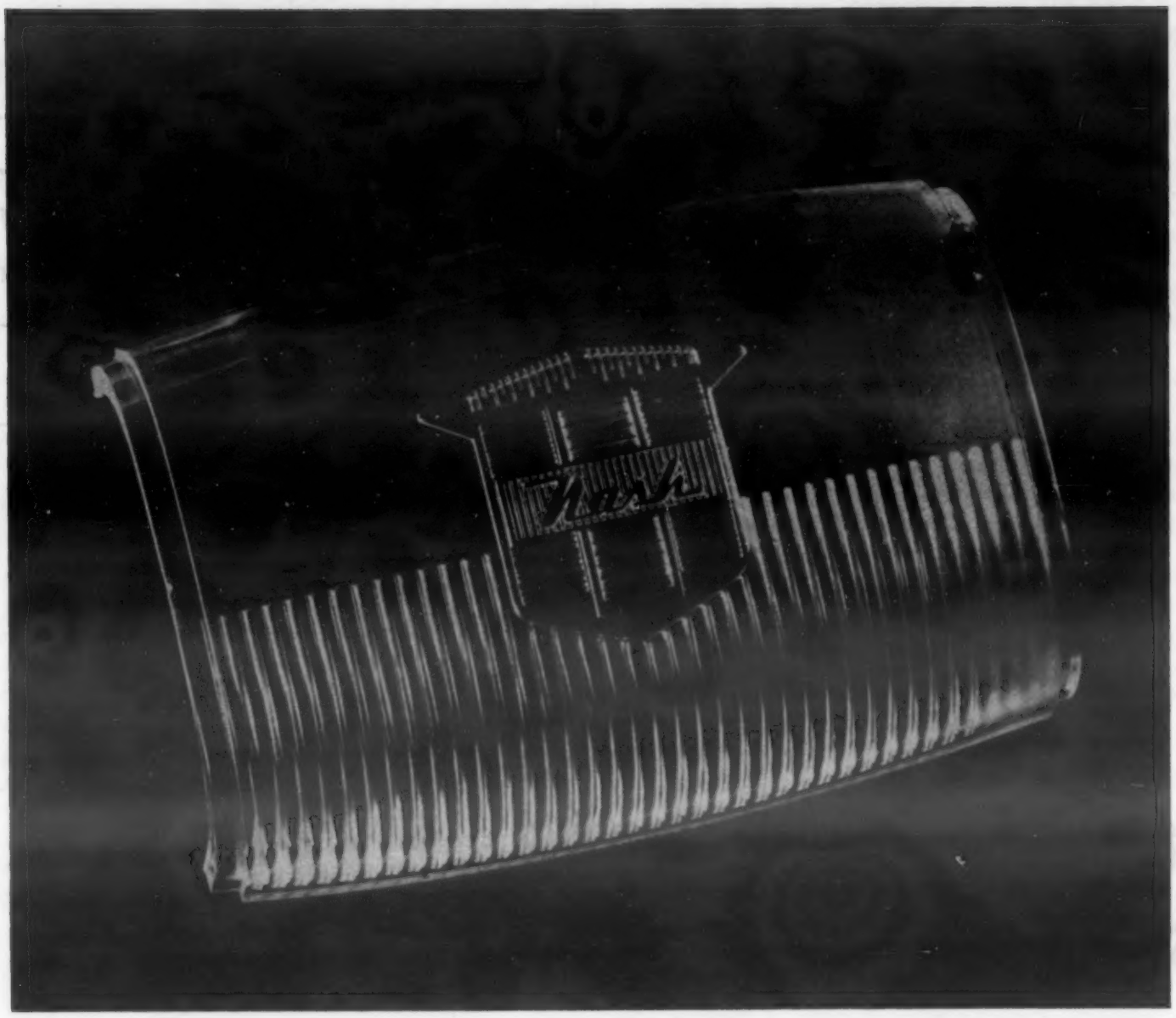
Several years ago, a study by Nash-Kelvinator Corp. revealed that polystyrene plastics would be excellently adapted for many automotive uses. However, major disadvantages ruling out such uses were: proneness to scratching and difficulty in removing scratches by polishing; destructive action of common cleaner fluids, gasoline and oil; and electrostatic attraction for dust.

After years of unsatisfactory experiments, Nash-Kelvinator Corp. employed the Bjorksten Research Laboratories to work out a practical solution to this problem. The assignment proved difficult since the proposed treatment was required to be applicable speedily by production line methods at temperatures so low that warping of the material was impossible. A complete optical fusion was required. The types of polystyrene employed included some quite unstable modifications in highly strained condition.

The Bjorksten Research Laboratories have now solved this problem in developing a low temperature polystyrene surface cementation process known as Logoquant.

Logoquant treatment can be applied by production line methods using standard equipment at a cost in the range of 1¾ to 7¢ per sq. ft. The economies gained by using Logoquant treated polystyrene instead of methacrylate or cellulose ester type plastics are in the order of 30 to 50¢ per sq. ft.

The several pertinent Bjorksten patent applications are assigned to Nash-Kelvinator Corp. Nash-Kelvinator, in turn, did not wish to monopolize a development so broadly applicable in many industries. Therefore, Nash-Kelvinator has granted a manufacturing license to the Bee Chemical Co., Chicago, which is now in a position to supply the Logoquant treatment products to any plastic manufacturer or user who wishes to employ it.



This molded polystyrene automobile part has not been treated. Attempts to polish scratched areas with solvents spoiled the surface, as can be seen at the right end.

Methods of Application

Logoquant treatment is carried out either by rapid dipping or spraying and subsequent low temperature fusion under infra red lamps. These lamps are preferably so spaced that the air temperature is 95 to 105 F and the surface temperature of articles being treated is about 125 to 135 F. The process is completed in 15 to 20 min. The process is not highly critical. If the relative humidity is less than 60%, the use of infra red warming may even be dispensed with entirely.

Logoquant treated polystyrene is non-toxic, and can be used in direct contact with food materials. The flash point of Logoquant solutions exceeds 120 F. They cannot be ignited by a spark below this temperature.

Modified Logoquants

In addition to the standard Logoquant treatment, modifications have been made, in which advantage is taken of the use of Logoquant as carrier for pigments, colors and other special agents.

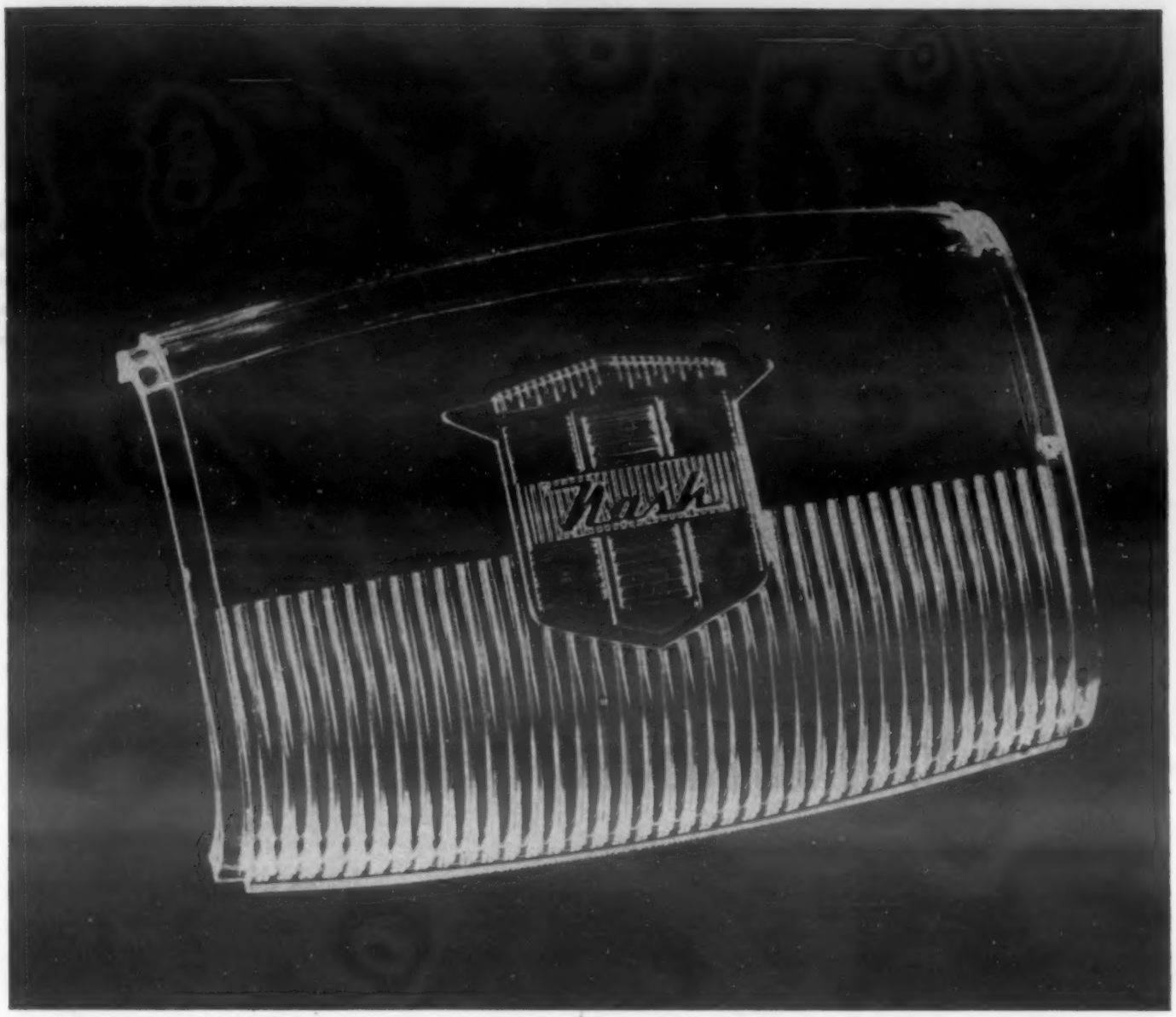
Logoquant UV is a transparent material, which prevents yellowing of polystyrene, by absorbing chemically active rays.

The treatment of transparent polystyrene at about 25¢ per lb., with pigmented Logoquant, produces articles of the same appearance as articles molded from pigmented polystyrene at about 34¢ per lb., and with greatly improved surface properties.

Clear, colored Logoquant permits entirely new decorative effects.

Logoquant opens the way for polystyrene resins to many fields, where previously the use of plastic has been discarded as uneconomical, or where much more expensive transparent plastics have been used. These include transparent instrument panels, or covers in the automatic airplane and radio fields, refrigerator parts, plastic tile, and other decorative uses in construction and architecture, transparent plastic containers of all kinds, novelties, and, finally, treated plastic sheets.

New fields of application for polystyrene resins now appear almost every week as a result of this discovery.



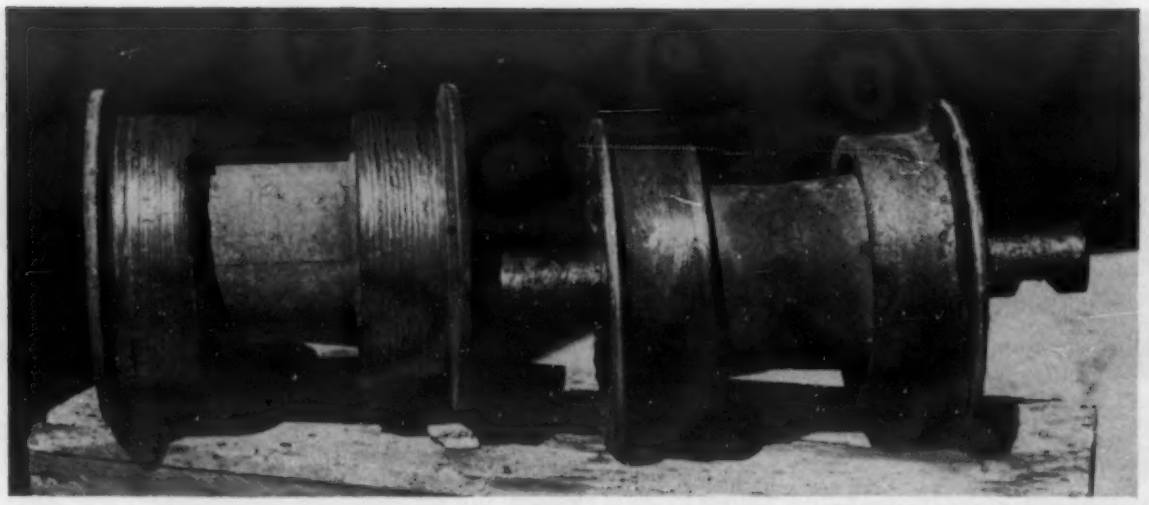
Identical with the piece shown opposite, except that the surface has been treated with Logoquant, this part resists scratching and is not affected by ordinary polishing solvents

Improvements in Surface Properties Obtained by Logoquant Treatment

This is a comparison between a representative untreated molded polystyrene, and the same surface, treated with Logoquant.

	Polystyrene Untreated	Same Logoquant Treated
Mar resistance (A.S.T.M. method D-673-44) (#80 Carborundum grit falling from 25 in., effect on surface transparency)	82%	100%*
Re-polishability, recovery of surface transparency from above test, on polishing with cotton cloth	Marred spot removed with difficulty	Marred spot readily repolished
Light transmission, % of normal incident beam	89%	92%
Light scattering, diffuse transmitted light (% Haze)	6.4	1.8
Attraction for dust	Positively charged, strongly attracts and holds dust	Negatively charged, repels a large percentage of dust particles
Resistance to solvents:		
Toluene	Attacked	Resists
Carbon tetrachloride	Attacked	Resists
Gasoline	Attacked	Resists
Mineral oil	Attacked	Resists

* *On the same scale, the mar resistance of a good spar varnish is 92% and of the hardest molded plastic we obtained commercially, at about 3 times the cost of polystyrene, is 107.*



Tractor rollers before (right) and after (left) being automatically hard-faced. Smoothness of deposit eliminates finishing operation.

New High Alloy Hard-Facing Materials Adapted to Automatic Arc Welding

NEW MATERIALS PREVIEW

IN THE PAST MECHANIZED HARD-FACING by arc welding has been confined largely to the use of mild steel and low alloys which can be fabricated as solid wire in coil form. The Stoody Company has now developed a tubular construction that makes possible the production of high alloy hard-facing materials for mechanized welding.

The new filler rods, made on special fabricating machines, consist of steel tubing containing the various alloying elements in granular form. The tube is flexible to allow for coiling and unreeling. The method of fabricating these hard-facing alloys also permits a wide variation in analysis to meet specific conditions involving simple abrasion, impact, corrosion or heat as well as any combination of these factors. Wires can be produced to operate under any given conditions. Some applications indicate the use of submerged arc welding, while in other cases an open arc would be more desirable from an economical or control standpoint.

The use of high alloy hard-facing materials is extended by a new flexible tubular type weld rod that is applicable to automatic arc welding methods.

At present there are eight different hard-facing wires in coil form. Some are similar to present manual electrodes which have been in common use for years, while others have been developed for a specific wear problem. The accompanying table gives their composition and some of their characteristics.

Most automatic electric heads now on the market will handle these new wires or can, without a great deal of difficulty, be adapted to them. One difficulty thus far encountered is the feed mechanism which up to now has been designed to handle solid welding wire. Since these wires are of tubular construction, they are subject to deformation under extreme pressure. For this reason the feed rolls should be grooved to fit exactly the wire being run through them so that the feed is positive without excessive pressure under all conditions. This assures an even, uninterrupted deposit. Positioning equipment, fixtures and jigs to operate with the automatic head are, as a rule, fairly simple. Some manufacturers prefer to furnish with their heads the fixtures required for specific jobs.

The use of the fabricated wires in coil form has now

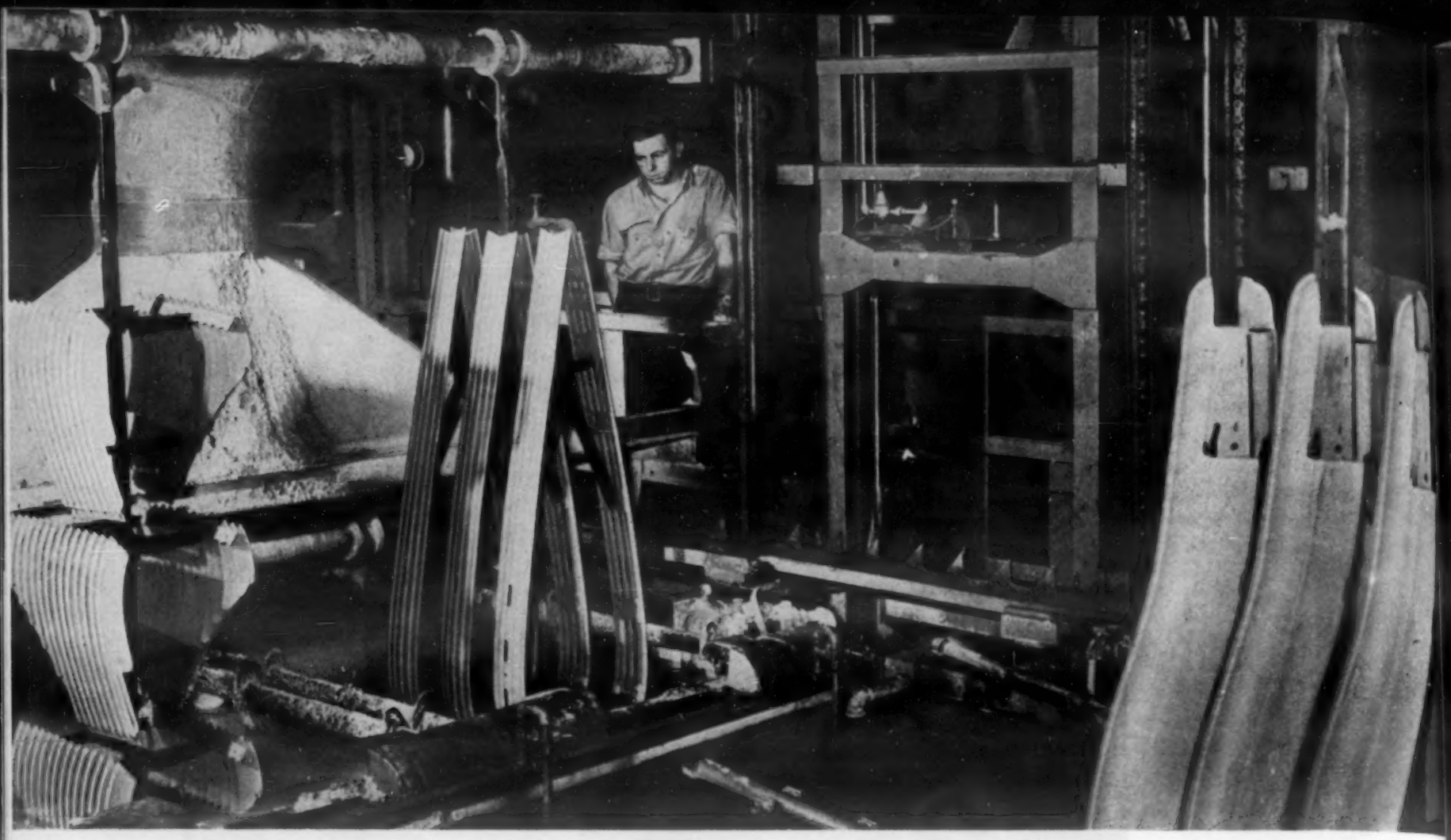


This 4-ft. cone has had 200 lb. of high alloy, hard-facing material applied to it by automatic arc welding.

become standard procedure in a half-dozen manufacturing plants. In others the alloys are undergoing extensive tests to determine their suitability for a wide range of hard-facing applications. Tool joints are now supplied by manufacturers with automatically applied bands of hard-facing placed at a critical position to increase the joint life several times over. Blades hard-faced by the automatic process have been added to one concern's carrying scraper as a standard equipment. Hard-faced auger flights on a rock boring machine offer another example of a protected product. It is believed that the life of ore handling and loading equipment which receives severe service could be increased at relatively low cost through automatic hard-facing. Other examples include conveyor screws, large bearings, grader blades, and shear blades.

Composition and Characteristics of the New Hard-Facing Alloys

Alloy	Composition, %	Characteristics
101	Cr 28, Ni 8, W 1.5, Mn 0.6, Si 1.0, C 2.0	For submerged arc. Machinable with carbide tools. R_c 32-36
102	Cr 5, W 1.5, Mo 1.5, Mn 0.75, Si 1.00, C 0.30	For submerged arc; multiple pass application. R_c 50-52
105	Cr 3, Ni 1.50, Mo 0.50, V 0.30, Mn 1.25, Si 0.50, C 0.25	For submerged arc; multiple pass application. Machinable with carbide tools. R_c 46-48
120	Cr 6, Mn 2, Si 1.2, Mo 0.1, Zr 0.05, C 1.0	For submerged arc. R_c 52-54
121	Cr 15, Mn 2, Si 1, Zr 0.25, C 2.5	For open or submerged arc. R_c 54-56
122	Cr 8, Mn 2.5, Si 1.0, Zr 0.05, C 0.75	For submerged arc. Self hardening. R_c 51-53
130	Tungsten Carbide 60, steel 40	For open arc. Ultimate abrasion resistance. Moh's scale. 9-10
Stoody Manganese	Mn 14, Ni 4, C 0.70	For submerged arc. Full Hadfield manganese steel properties.



This fully automatic plating machine is working on automotive parts. Here parts are shown going into and out of plating and cleaner tank

Materials and Requirements for Decorative and Protective Plating

by **NELSON G. MEAGLEY, Assistant Chief Metallurgist, Willys-Overland Motors, Inc.**

SINCE THE AUTOMOTIVE INDUSTRY is probably the largest single user of plated products, its experience and practices serve to set an example for industry in general. This discussion will be limited to the most common types of industrial plating and will not cover such plates as gold and silver.

Automotive plating is of two types, decorative and nondecorative. The first becomes a part of the styling of the vehicle and is used on exposed surfaces. The second is restricted to corrosion protection only and, on passenger cars, is only used on non-visible parts.

The present trend is toward thicker coating with resultant longer protection. Generally, specifications for decorative plating is intended to give 4 or 5 years protection in the northern United States climate (latitude 40). Nondecorative plating should give somewhat better protection than the decorative. Various parts of the world have widely different corrosion rates due to high humidity, industrial atmospheres, sea air, high temperatures, soils (alkaline or acidic), or fungus growth. There is no agreement among authorities as to the amount of plating required to protect metals under these different conditions.

Plating sometimes fails through lack of adhesion between the various coats with resulting blisters, peeling, or other surface defects. The general service type of failure, however, is through galvanic corrosion between the base and plated metals. If the base metal is anodic in the couple, such as steel plated with nickel, then small pin holes in the coating will become enlarged in corrosive media. Iron in the pin hole will be plated out and onto the nickel.

When the plating is anodic to the base metal, such as cadmium or zinc on steel, a corrosion product from the coating will spread out over the pin holes and other breaks in the coating. The coating will expand itself into the formation of corrosion products before action will begin upon the iron below. This serves to give extended protection by thin and relatively inexpensive coats. Unfortunately, the corrosion product is unsightly and automotive practice is to limit the use of cadmium or zinc plating on passenger vehicles to non-exposed parts.

The extent of the pin holes in a nickel plated surface can be estimated through an accelerated corrosion test performed in a standard salt spray cabinet. Re-

Base metals, service conditions and the location in which the finished product will serve all have a share in determining what plating materials shall be used.

sistance to corrosion of the plating is measured by equipment and methods prescribed under ASTM designation B-117, which is usually a part of automotive specifications for nickel or chromium plating. Cadmium and zinc, due to their anodic position, usually must be subjected to lengthy time periods in the salt spray test and this is impractical for production control, hence is not generally a part of specification for cadmium or zinc plating.

Methods for the measurement of plating thickness are prescribed in ASTM designation A-219. Chromium thickness is generally determined by a spot test, while nickel, copper, cadmium and zinc are measured by microscopic examination of cross sections. The magne-gage, an instrument which measures the forces required to sift calibrated magnets from a plated surface, is widely and satisfactorily used as a rapid method of measuring plating thickness.

Materials Used

Decorative plating for automobiles is either bright nickel or chromium. These are the same, except the chromium is a flash coating over the nickel (only 0.00001-in. thick) and prevents tarnishing of the nickel. It is assumed that there is no additional protection added by this chromium plating.

Nondecorative plating is generally cadmium or zinc, with cadmium considered about twice as effective as zinc. For battery bolts, lead plating is used.

Plating thickness and its measurement, regardless of method used, apply only to significant surfaces of the part. Significant surfaces should be shown on the drawing or be agreed upon by the purchaser and vendor. When parts over 300 Bhn. are plated the material should be baked for 4 hr. at 400 F to eliminate hydrogen.

Although there are different opinions among the car manufacturers as to the plating requirements for the various parts of an automobile, the following list is a typical specification for passenger vehicles.

Decorative Plating

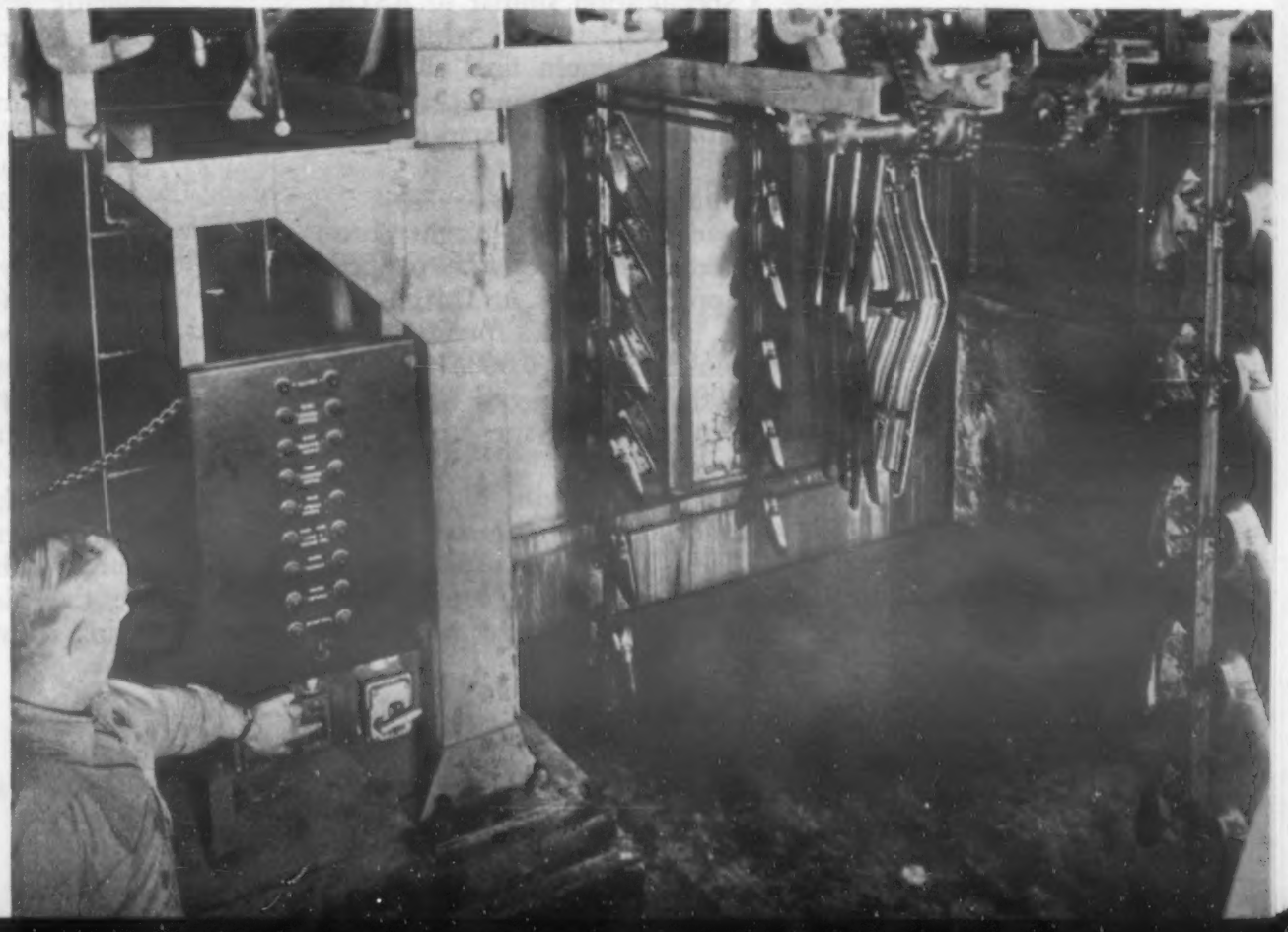
To localize specific requirements, several types of automotive products will be discussed as to both the materials and plating specifications.

(1) Bumpers, bumper guards, hub caps, head lamps, front end ornaments, grilles, door handles.

(a) When made from steel, the above parts are bright chromium plated to a specification similar to ASTM designation A-166 Type F.S. This provides for copper plus nickel plating of 0.00125 in., of which at least 0.0006 in. of the final coat must be nickel. The chromium must be 0.00001 min. This coating must withstand 72 hr. of salt spray by ASTM B-117 methods.
Bumpers, bumper guards, and hub caps are sometimes considered to require additional protection. The practice then is to plate so as to withstand 96 hr. salt spray without failure.

(b) When the head lamps, front end ornaments, grilles, or door handles are made from zinc-base die castings, a specification similar to ASTM B-142 Type F.Z. is generally used, which provides for copper plus nickel of 0.0005 in. min. Chromium is 0.00001 in. min. This plating must withstand 48-hr. salt spray.

(c) When above parts are made from copper or copper alloy, a specification similar to ASTM B-141 Type F.C. is used. This provides for 0.0005-in. min. final thickness of nickel with minimum



Complete control over every step of the plating process is one means of attaining high quality finishes. This panel controls one entire plating line. (Photos: Courtesy of George L. Nankervis Co.)

Automotive Plating Standard

	Severe Exposure	Medium Exposure	Mild Exposure
Example	**Bumpers and Hub Caps**	**Parking Lights**	**Inside Trim**
Chromium Plate on Steel	A.S.T.M. Type F.S. Cu plus Ni—0.00125 in. Min. Ni.—0.0006 in. Chromium—0.00001 in. Salt spray—72 hr.	A.S.T.M. Type K.S. 0.00075 in. 0.0004 in. 0.00001 in. 48 hr.	A.S.T.M. Type Q.S. 0.0004 in. 0.0002 in. 0.0001 in. 16 hr.
Chromium on Zinc	A.S.T.M. Type F.Z. Cu plus Ni—0.00125 in. Cu, min.—0.0004 in. Ni, min.—0.0005 in. Chromium—0.00001 in. Salt spray—48 hr.	Type K.Z. 0.00075 in. 0.0003 in. 0.0003 in. 0.0001 in. 32 hr.	Type Q.Z. 0.0005 in. 0.0002 in. 0.0003 in. 0.00001 in. 16 hr.
Chromium on Copper Alloy	A.S.T.M. Type F.C. Ni, min.—0.0005 in. Chromium—0.00001 in.	Type K.C. 0.0003 in. 0.00001 in.	Type Q.C. 0.0001 in. 0.00001 in.
Zinc on Steel	A.S.T.M. Type G.S. Min. Zn—0.001 in.	Type L.S. 0.0005 in.	Type R.S. 0.00015 in.
Cadmium on Steel	A.S.T.M. Type N.S. Min. Cd—0.0005 in.	Type O.S. 0.0003 in.	Type T.S. 0.00015 in.

chromium 0.00001 in. Salt spray resistance is not specified.

(2) Hood ornaments, tail lights, parking lights.

(a) When made from steel, the specification is bright chromium plate and is similar to ASTM A-166 Type K.S. This specification requires minimum copper plus nickel 0.00075 in. with minimum final nickel 0.0004 in. Chromium is 0.00001 in. The salt spray resistance required is 48 hr.

(b) When made from zinc-base die castings, the plating specification is generally similar to ASTM B-142 Type K.Z., which specifies copper plus nickel 0.00075 min. (copper minimum 0.0003 in. and minimum final nickel 0.0003 in.) with chromium 0.00001 in. min. The required salt spray resistance is 32 hr.

(c) When made from copper or copper alloy, a specification similar to ASTM B-141 Type K.C. is used which provides for a minimum final thickness of nickel, 0.0003 in., and chromium 0.00001 in. Salt spray resistance is not specified.

(3) All inside chromium-plated parts.

(a) When made from steel, bright chromium plate is specified with requirements approximately ASTM A-166 Type Q.S. This provides for minimum copper plus nickel of 0.0004 in., final nickel 0.0002 in. min. and chromium 0.00001 in. min. Salt spray resistance of 16 hr. is required.

(b) When the parts are zinc die castings, the specification approximates ASTM B-142 Type Q.Z. This specification provides for minimum copper plus nickel of 0.0005 in., copper 0.0002 in. min. and nickel 0.0003 in. min. The chromium is 0.00001 in. min. Required salt spray resistance is 16 hr.

(c) When made from copper or copper alloy, a specification similar to ASTM B-141 Type Q.C. is generally used. This provides for a minimum final thickness of 0.0001 in. nickel and chromium 0.00001 in. Salt spray resistance is not specified.

When the tarnishing effect of nickel plate is not objectionable, nickel plate is specified in place of chromium, and the above specification numbers, salt spray resistance time and plating thicknesses (except for the final chromium) are used.

Nondecorative Plating

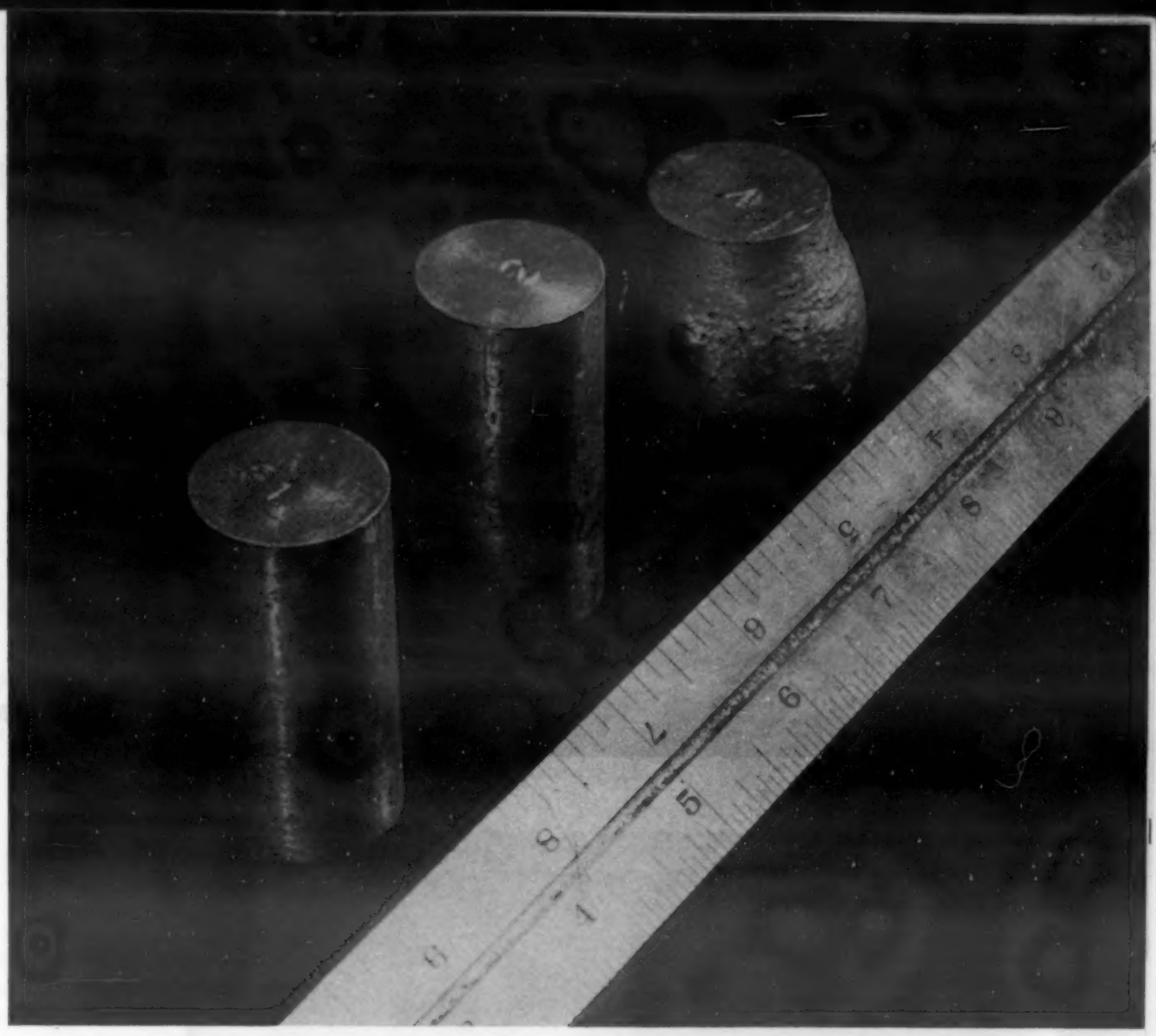
For nondecorative plating such as on nuts, washers, inside of hub caps, etc., zinc or cadmium is specified.

(1) *For severe outside exposure,* the specification generally approximates ASTM A-164 Type G.S. for zinc, which requires a minimum thickness of 0.001 in. or A-165 Type N.S. for cadmium, which requires a minimum of 0.0005 in. thickness.

(2) *For mild outside exposure,* the specification generally approximates ASTM A-164 Type L.S. for zinc (minimum thickness 0.0005 in.) or A-165 Type O.S. for cadmium (minimum thickness 0.0003 in.).

(3) *For inside exposure,* the specification generally approximates ASTM A-164 Type R.S. for zinc or A-165 Type T.S. for cadmium. In both cases the plating thickness is 0.00015 in.

(4) *For battery bolts,* and other plating to resist sulfuric acid, lead is used. About 0.001 in. of lead is generally considered as the minimum required although some specifications do not give the plating thickness but require the coating to resist chemical tests.



The die alloy is shown here in three conditions. Left, a pig before the load test; center, a nitrogen cooled specimen subjected to a load of 5,650 lb.; right, a pig that was subjected to the same load, but which was not cooled.

Soft Alloys Used to Make Short-Run Sheet Metal Dies

by **KENNETH ROSE**, **Engineering Editor, Materials & Methods**

EXPERIMENTAL DEVELOPMENT OF DIES for metal forming is sometimes a long and costly procedure. Original die design may require modification after test runs have shown the nature of the defects, and changes in the hardened steel dies ordinarily used may require weeks to accomplish.

The ideal experimental die material would be one that could be shaped quickly, would be soft enough to permit changes to be made in the die form without the necessity of an elaborate machine set-up, or of an annealing and rehardening, with its attendant warpage. At the same time, it must be hard enough to withstand the pressure of the presses during the forming operation.

Until recently, experimental dies were made of tool steel, just as were production dies. Cast iron

Nitrogen hardened soft metals can be used to produce dies and sample parts within 24 to 48 hr., as compared to weeks required if the usual die materials were used.



The soft-metal die here is being hardened by chilling in liquid nitrogen to —320 F.



Experimental runs using the hardened dies are made on an Olsen testing machine which serves as a press.



Here the metal blank is pressed into shape. The normally soft dies have ample strength for light work.



Two halves of an experimental die made of Wood's metal, with one run of small metal parts.

permitted quicker forming of die blanks, and was favored for both experimental and production dies when other factors permitted. During the war the zinc-base alloys offered under the general trade name Kirksite were advantageous for quick production of both experimental and light production dies.

From the Research Laboratories of Ford Motor Co. comes the announcement of a new experimental die material, and an unusual process for using it. The die material is a variation of the Wood's metal composition, sold under the trade name Cerrobend, which at room temperatures is softer than lead. It melts at about 130 F. By chilling to very low temperatures, however, the metal develops a hardness comparable to that of brass. This is sufficient for several pressings by small experimental dies.

The working hardness is obtained in the engineering laboratory by immersing the die in liquid nitrogen, at a temperature of —320 F. A few minutes in the liquid is all that is required to chill the die to a temperature at which it may be used for forming aluminum or light sheet steel. The die warms rapidly when removed from the bath, but from six to ten pressings may be made before the temperature rise makes the die too soft for use. All that is necessary when additional pressings are required is to immerse the die in the liquid nitrogen again. Warpage is inconsequential, say the Ford engineers, and the chilling can be repeated indefinitely.

To make a die of the low-melting alloy, the wooden pattern may be used to make a mold in a fine-grained molding material, usually plaster of Paris. The male half of the die may conveniently be made first. This is cast in the usual way, a procedure simplified by the low melting point of the alloy. Any minor repairs may be made with a soldering iron, using it carefully because of the ease with which the metal is fused.

A sheet of aluminum the same thickness as the piece to be formed, and blanked out where necessary, is then placed over the male half of the die, and pressed against a rubber blanket to give it the die form. Die and aluminum piece are then walled off with plaster or modeling clay so that the cavity corresponds to the female die form. Locating pins to secure alignment may be inserted at this time. The female die is then cast, the aluminum piece serving to preserve the proper spacing between the die halves and also to prevent the molten metal from fusing the half previously cast. Touch-up repairs are made on the new casting if required.

Readying the completed die for use consists of chilling in the liquid nitrogen bath for a few minutes, as stated. When cooled to the temperature of the liquid the alloy develops a strength of about 25,000 psi. Strength falls off rapidly as the temperature rises, however, and the dies must be used immediately after chilling. They are handled with asbestos gloves to prevent frostbite to the users. Sheets of asbestos above and below the dies in the press help to retard the rise in temperature.

An Olsen testing machine is frequently used at the Ford laboratory for making test pieces with the dies. In this way die pressures can be determined during the experimental runs without use of complicated apparatus.

After half a dozen or more of the parts are pressed by the chilled dies, a second chilling is required. The samples obtained are studied, and any corrections in the die form may be made after the dies warm to room temperature, when the metal may be cut with a pocket knife. More than 250 stampings may be obtained for Cerrobend dies before it is necessary to make new ones. Shaping with hand tools makes possible great savings in time and money in these experimental dies, as compared with costs when the harder die materials are used.

Small dies made of the conventional die steels have required from six to eight weeks for production, Ford engineers say. With the chilled dies of soft metal, the dies can be made and sample parts produced in from 24 to 48 hr.



The furnace at the left is typical of those used to preheat tool steels. The door ledge is particularly suited for warming tools before placing them in the furnace.

Proper Precautions Eliminate Cracking in Tool Steel Heat Treatment

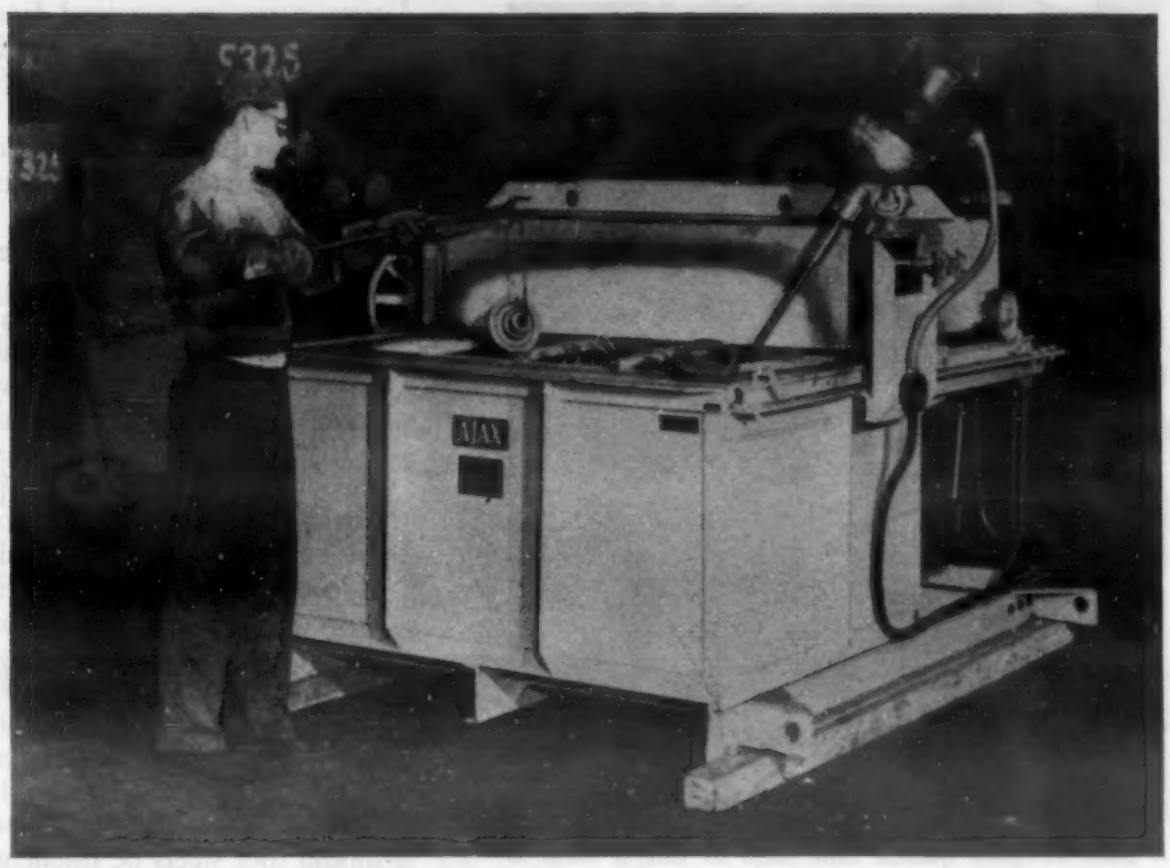
by S. D. SMOKE, Associate Editor, Materials & Methods

Much tool steel is irretrievably lost through careless and improper techniques in heat treating. Here are some points to watch to help you eliminate such unnecessary waste.

THE CRACKING OF TOOL STEELS during and after heat treatment is a problem faced in most shops handling these types of steels. The natural tendency is to blame the steel, but often the trouble can be traced to careless or improper procedures during the various heating and cooling cycles.

Treatment cracks are extremely costly, since most heat treating is done after considerable time has been spent in machining or otherwise forming the tool steel part. Cracked tool steels rarely can be salvaged; thus both the labor and material are a complete loss.

A better knowledge of the effect of alloying elements plus improved steel-making facilities and practices results in the tool steels of today being vastly superior to those of a few years ago. The improved steels are more sensitive to treatment and thus must be handled more precisely during treatment.



Hooks which are subjected to the same heating and cooling cycles as the tools may be used to eliminate handling of heated pieces with cold tongs.

Elaborate heat treating procedures are available for all tool steels either through the suppliers or in technical publications. With this information it is a simple matter to set up a heat treating procedure. Generally overlooked by both supplier and user are those supposedly little things which can make treatment a success or failure. It is the purpose of this article to elaborate somewhat on those steps which help to assure completely successful heat treatment of tool steels.

One of the first oversights in starting to harden tool steels is making certain the structure of the steel is correct. The material should have a completely spheroidized carbide structure to reduce the possibility of cracks due to hardening strains. Carbon tool steels should be normalized and annealed before hardening and the more highly alloyed tool steels should be completely spheroidize annealed. As a precaution when purchasing, annealed bar stock should be specified as requiring a completely spheroidized structure.

Heating

Cracks resulting from faulty heating generally are caused by one of three reasons: uneven heating, overheating, or underheating.

Proper preheating is the first step taken to assure uniform heating. Tools to be treated should be warmed, either in a low heat furnace or by setting them on or near a hot furnace, before placing them in a preheat furnace. Depending upon the tool steel being treated, and the hardening temperature, warming temperatures will vary from about 400 to 800 F; preheating temperatures from 1200 to 1600 F.

Steels requiring a hardening temperature above 1800 F should be preheated in a separate furnace or preheat chamber to between 1500 and 1600 F, thoroughly soaked at this temperature and then brought rapidly to the hardening temperature in the hardening furnace. Steels having lower hardening temperatures should be preheated to between 1200 and 1400 F, then heated slowly and uniformly to the hardening temperature.

Instruments should be depended upon to control and record accurate temperatures. However, a visual check is helpful to determine hot and cold spots. Because hot and cold spots are easily seen, any pyrometric errors which exist can be caught before damage is done in quenching. Cracks due to uneven heating have a circular appearance on the quenched tool steel and show up in areas which have been heated unevenly.

Improper or inadequate temperature control is the cause of both overheating and underheating. Both faults can cause cracking.

Overheating causes two common types of flaws in tool steels. In one case the corners of the tools deteriorate rapidly. Most flaws, however, are not visible to the unaided eye, appearing as a series of minute cracks along corners of the piece after quenching.

Since all hardening temperatures are well above the critical range, it is obvious that failure to provide



A plant-designed quench tank such as this is ideal in maintaining adequate circulation of a clean, cool quenching medium.

sufficiently high temperatures will result in heat treated parts having lower physical properties than desired.

Salt baths and lead baths reduce heating times materially. The use of such baths, however, does not lessen the need for careful preheating, adequate soaking and holding at proper temperatures.

Quenching

Quenching is often responsible for distortion, warpage and cracking. The warpage and distortion are caused by internal stresses resulting from differences in temperature between the surfaces and the center of the piece being quenched. When these same stresses exceed the strength of the steel in localized areas, cracking results.

The actual steps in quenching procedure for any tool steel are well known, or easily obtained, but there does not seem to be sufficient emphasis placed on important details of the quenching procedure. For instance, there should be no delay in quenching the part after removal from the hardening furnace; good circulation is essential in the quenching bath for rapid heat removal. Also, the quenching bath should be kept clean and at the proper temperature; the tools should not be removed from the quench until they have cooled to the correct temperature, and, finally, the parts should be tempered immediately after quenching.

It is important that there be no delay between the time parts are removed from the hardening furnace and their quenching. In addition to risking cracking through such delays, the effectiveness of the quench is impaired.

Good circulation of the quenching bath is necessary to provide rapid and uniform heat transfer from the entire surface of the piece being quenched. Cracking results from stresses set up through unequal heat transfer from different areas in the same tool.

Dirt, scum or scale which might adhere to a piece of tool steel being quenched in a dirty bath will result in soft spots. Soft spots will, if passed unnoticed, cause premature failure of finished tools.

It is vital that treated parts be removed from the quenching bath at the proper temperature. Care is particularly necessary with oil quenched steels where the cooling rate is much slower in the final stages of cooling and transformation is taking place at a slower rate than in brine or water. Most tool steels should be removed from the quench bath at temperatures between 200 and 400 F. (An exception are high-speed steels quenched in salt at 1000 to 1050 F.) Accurate measurement of removal temperatures from brine, water and oil through the use of temperature indicating crayons is recommended. In no event should tool steels be quenched until they are cold.

One of the most common causes of cracking is due to careless tempering of quenched steels. Most people concerned with its treatment realize the dangers inherent in unrelieved quenching stresses, but still there remains considerable laxity. Generally, when trouble arises, it is because the parts are not quenched soon enough after quenching, or because tempering is not for a period sufficiently long completely to relieve the residual stresses set up in quenching. In either case cracks may appear at any time, from immediately after the quench until sometime after the tool has been placed in service. All tool steels should be tempered immediately after quenching and before cooling to below 200 F.

Ideally, a tempering furnace would be awaiting tools removed from the quench. The furnace would be set for the temperature of the quenched tools. Unfortunately this is not always possible, so a steam chest or heater should be available to provide storage space, at 200 to 250 F, for the tools until they can be tempered. Even with satisfactory hot storage facilities, tempering should not be delayed for more than an hour or two.

Tempering is normally considered a reheating operation to attain desired physical properties. However, tempering has the important task of relieving residual stresses caused by quenching.

Many tools are reforged, remachined or reground to obtain maximum service. It is wise to anneal or stress relieve the parts before each of these operations and again before rehardening. Tool steels improperly conditioned invariably will crack. The steels are extremely sensitive to working and machining strains as well as to thermal shock in heating and cooling.

All of the warnings presented here are important to satisfactory heat treatment of tool steels. Each precaution is necessary, and if all steps are properly watched cracking will be materially reduced, if not completely halted.

MATERIALS & METHODS MANUAL

35

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Aluminum Alloy Castings

by Floyd A. Lewis

The advantages of aluminum are available to the materials engineer and designer in a variety of cast forms. However, there are several considerations which must guide him before he decides which casting method should be used for the part to be made. In this manual the author discusses the various alloys, advantages and disadvantages of the different casting methods and design limitations, and gives information on finishing of all types of castings.

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Materials & Methods, March 1948

(Published since 1929 as Metals and Alloys)



Aluminum's unparalleled record of achievement in World War II, notably in aircraft but also in many other types of military equipment, has stimulated a steadily increasing variety of peacetime applications of this versatile light-weight metal and its alloys. Continuing scarcities of other materials and the fact that more engineers and designers became acquainted with aluminum and its unique properties during the war are significant factors in this increasing demand.

Not only is the use of aluminum expanding in fields where it already was firmly established, but it also is invading fields heretofore considered the sole province of other metals and alloys. Aluminum alloy castings occupy a prominent place in this picture. To meet the rigid specifications laid down for castings to be used in military equipment, foundrymen expanded and modernized their plants, procured elaborate control equipment, and developed improved production procedures. As a result, the aluminum foundries are prepared to produce better aluminum castings for a wider variety of peacetime uses than ever before.

Several other factors currently are favoring an increased use of aluminum castings. First is the matter of cost; in spite of generally spiraling prices on practically all materials and products, the price of aluminum is at the lowest level in its history—only 15¢ a lb. in ingot form. Second is the ease with which aluminum can be machined; in these days of higher wage rates, the saving in machining and finishing costs alone may permit finished aluminum castings to be brought to the point of assembly at a lower over-all cost than even iron castings. A third factor is the lower handling costs which aluminum's lighter weight makes possible.

Aluminum's unique properties are well known. Light weight, high electrical and thermal conductivity, excellent resistance to corrosion, desirable combinations of mechanical properties, ease of machining, and variety of attractive surface finishes are the outstanding characteristics that place alumi-

Fine detail can be achieved in aluminum castings. The excellent reproduction of design details can be seen in this architectural casting made of aluminum.

Aluminum Alloy Castings

Introduction

num and its alloys at the top of the list for many casting applications. Not so well known are some of the high-strength and special-purpose alloys of relatively recent origin. Many of these have proved themselves in rigorous wartime applications and now stand ready to turn in equally creditable peacetime performances. For example, heat-treated aluminum alloy castings can now be produced having tensile strengths of the order of 50,000 psi. and hardness values as high as 140 (Brinell).

For many applications aluminum is the only material having the required combination of properties. In others, because of its lighter weight, finished castings of aluminum may cost less than comparable castings of other metals that are appropriate for the job. For moving parts, aluminum's lighter weight means better performance and lower operating costs. Sometimes aluminum is ruled out solely on a cost basis. In many such instances, reconsideration with full regard to all the factors mentioned in the preceding paragraphs may point to the use of the lighter metal with all its desirable characteristics.

When considering the substitution of aluminum for some other metal, the design should be carefully studied with particular regard to certain factors closely related to aluminum's distinguishing properties. Too often substitutions have been made without adequate consideration of these factors; as a result, the full potentialities of aluminum often are not realized because the designs are unsuited to it. Consultation with an experienced foundryman will prove helpful in this study, as he often can suggest design changes that will lead to simpler and more economical production in the foundry. (Throughout this article when the word "aluminum" is used in a general sense it is intended to embrace all alloys in which aluminum is the predominating element.)

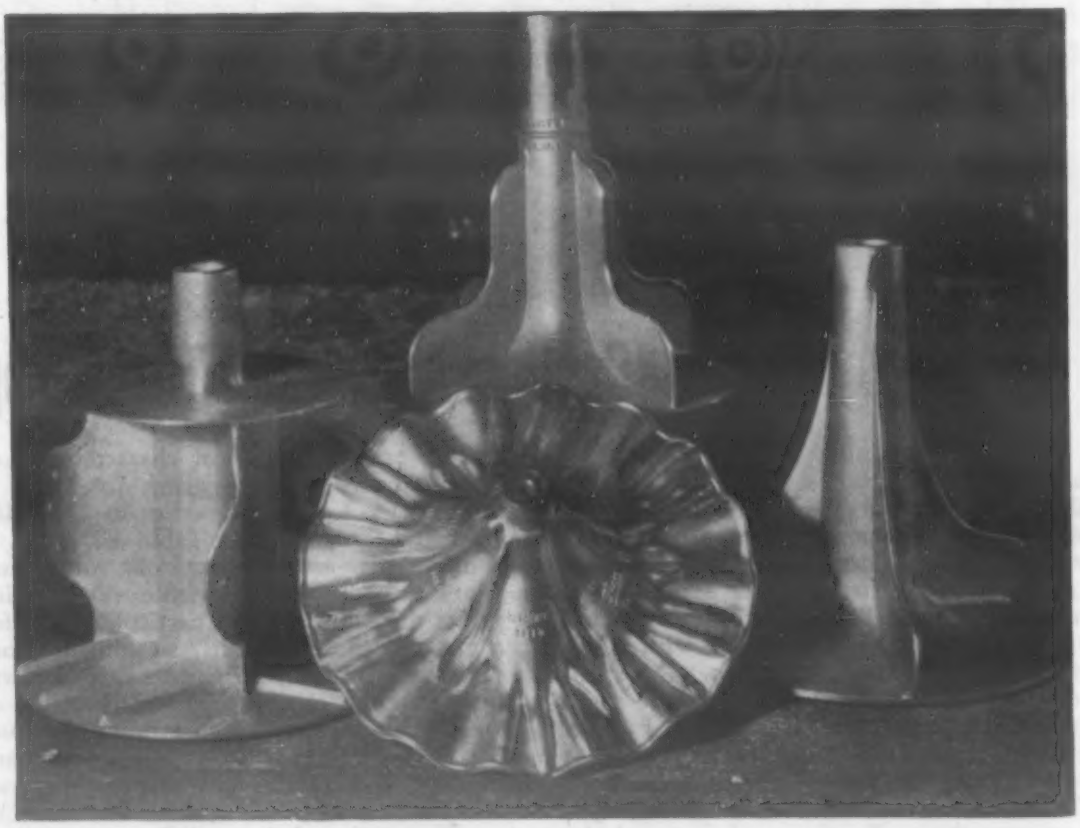
Principal Alloying Elements

Out of the large number of elements that can be alloyed with aluminum, practical considerations have limited them to comparatively few in present commercial alloys. These are principally copper, silicon, magnesium, zinc and nickel, and to a lesser extent manganese, chromium, titanium and tin. Pure aluminum has low mechanical strength and poor casting qualities, and the different alloying elements, either singly or in combination, are added for the purpose of providing improved mechanical, physical or casting characteristics.

Copper and silicon are added by far the most often and with few exceptions in the largest proportions. In general, the aluminum-silicon alloys show greater improvement in casting qualities but not quite as high mechanical properties as those in which copper or magnesium are the principal alloying agents. Zinc has been used to a considerable extent in Europe because of its lower cost, but has had more limited use in the United States. Nickel is used chiefly in complex alloys to aid in retaining mechanical properties at elevated temperatures. Magnesium has come into more common use in recent years as improved methods of casting these alloys have brought lower cost. In fact, some of the highest-strength aluminum alloys are those containing this extremely light metal.

The remaining alloying elements are added for special purposes where special characteristics are required and, in general, are used in small but carefully controlled proportions. Iron is one of the impurities in commercial aluminum, and in only a very few alloys is any iron intentionally added. None of the alloys show improvement in resistance to corrosion as compared with pure aluminum, but some of them are equally resistant or practically so under most environments.

Some alloys reach their optimum properties in the as-cast condition, but the higher-strength and special-purpose alloys usually depend on heat treatment to develop their superior or special characteristics. Heat-treatable alloys, as those responding to heat treatment are called, all contain at least one element that is more soluble in aluminum at elevated temperatures than at room temperatures. For best results this element, such as the 4.5% copper of the aluminum-copper series, is added in amounts that are completely soluble at temperatures below the melting point of the alloy.



Consumer preference has led to the widespread use of aluminum washing machine agitators. Several different types are among this group of cast aluminum agitators.

Table I—Composition of Commercial Aluminum Casting Alloys

Alloy Designation[1]	Nominal Composition, % Balance Aluminum						Heat Treatable	Sand, Permanent Mold, or Die
	Copper	Silicon	Magnesium	Zinc	Nickel	Others		
C1	4.5	—	—	—	—	—	Yes	S
CG1	10.0	—	0.25	—	—	—	Yes	S & P
CN21	4.0	—	1.5	—	2.0	—	Yes	S & P
CS4	4.5	2.5	—	—	—	—	Yes	P
CS21	9.5	4.0	1.0	—	1.0	—	No	P
CS22	7.0	2.5	—	2.5[2]	—	—	No	S & P
CS23	6.5	5.5	0.4	—	—	—	Yes	P
G1	—	—	4.0	—	—	—	No	S
G3	—	—	10.0	—	—	—	Yes	S
GS1	—	1.8	4.0	—	—	—	No	S & P
GZ1	—	—	4.0	1.8	—	—	No	P
S1[3]	—	5.0	—	—	—	—	No	S & P
S2[3]	—	5.0	—	—	—	—	No	S & P
S4[3]	—	5.0	—	—	—	—	No	D
S5	—	12.0	—	—	—	—	No	D
S9[4]	—	12.0	—	—	—	—	No	D
SC1	4.5	5.5	—	—	—	—	No	P
SC2	3.5	5.0	—	—	—	—	No	D
SC5[4]	3.5	5.0	—	—	—	—	No	D
SC6[4]	3.5	8.5	—	—	—	—	No	D
SC7	3.5	8.5	—	—	—	—	No	D
SC8	3.5	6.3	—	1.0[2]	0.5[2]	—	Yes	S & P
SC21	1.25	5.0	0.5	—	—	—	Yes	S & P
SC41	1.5	12.0	0.7	—	—	0.7 Mn	Yes	P
SC42	1.5	7.8	0.4	—	0.2	0.4 Mn	Yes	S
SG1	—	7.0	0.3	—	—	—	Yes	S & P
SG2[4]	—	9.5	0.5	—	—	—	No	D
SG3	—	9.5	0.5	—	—	—	No	D
SN41	1.0	12.0	1.0	—	2.5	—	Yes	P
ZG41	—	—	0.6	5.5	—	0.5 Cr	Yes	S

[1] *From 1946 Tentative Specifications of Am. Soc. Testing Materials.*

[2] *Maximum values.*

[3] *Alloys S1 and S2 are identical except that impurities in S1 are held lower limits, giving it greater resistance to corrosion. S4 is a similar alloy for die casting.*

[4] *Impurities in these die casting alloys are more closely controlled than in the other die casting alloys of otherwise identical composition. These alloys are suitable for use only in cold-chamber machines.*

Casting Alloys and Their Properties

Some 30 aluminum alloys are in regular use for casting purposes, but perhaps less than ten are filling the majority of needs where special characteristics are not involved. Sand, permanent mold and die casting alloys included in the specifications of the American Society for Testing Materials are listed in Table I with their nominal chemical composition. Other alloys deviating somewhat from these compositions have been introduced by the various producers. With the exception of a few new classes of alloys introduced since the ASTM specifications were formulated, however, these alloys cover in general the same fields of application as those listed in Table I.

The principal physical characteristics of the various alloys are given in Table II and the mechanical properties in Table III. As can be noted from Table III, there is considerable overlapping of mechanical properties. Therefore, within rather wide limits the selection of a particular alloy for a given purpose is greatly simplified. Once the mechanical requirements are known, final selection can be made on the basis of which alloy in the chosen group most completely will meet the other requirements.

Aluminum of commercial purity (about 99.5%) has a specific gravity of 2.71. The specific gravity of the various casting alloys varies but little from this value, as shown in Table II, and for practical purposes all these alloys may be considered to weigh about 0.10 lb. per cu. in. Commercially pure aluminum has an electrical conductivity of about 60% of that of the international annealed copper standard and a thermal conductivity of 0.52 in cgs units at a temperature of 25 C. Both properties have lower values in the alloys, the former ranging down to about 20% and the latter to about 0.20 in cgs units for the casting alloys.

For all alloys the modulus of elasticity is approximately 10,300,000 psi., the modulus of rigidity 3,900,000 psi., and Poisson's ratio 0.33. Values given in Table III for yield strength show the stress that produces a permanent set of 0.2% of the

initial gage length of the test piece. Endurance limits are based on 500,000,000 cycles of completely reversed stress using the R. R. Moore type of machine and specimen.

The relatively low modulus of elasticity, particularly as compared with iron and steel, means that deeper sections must be used where aluminum is loaded as a beam. By proper design, however, deflections in castings can be kept within desirable limits and at the same time weight savings of from one-half to two-thirds as compared with cast iron can be effected. The lower modulus of elasticity is an asset where impact loads are to be resisted, since in general the lower the modulus the greater the ability to absorb energy without permanent set.

In common with other materials, tensile strength, yield strength, and modulus of elasticity of aluminum alloys are lower at elevated temperatures than at ordinary temperatures. Some alloys, however, have better performance in this respect than others, as discussed later. At temperatures below ordinary levels, the mechanical properties are somewhat higher.

Aluminum castings will exhibit a certain amount of creep and growth under some conditions. Creep, or permanent deformation under long-time sustained loads, has been observed at or near the yield-strength, but practically none occurs at stresses of about half the yield-strength value or less.

On exposure to elevated temperatures many aluminum alloys exhibit an increase in volume, over and above normal thermal expansion, which is retained upon return to the original temperature. This phenomenon is called growth. The greatest increase in linear dimension observed so far is less than 0.2%; and, unlike cast iron which is subject to indefinite growth, aluminum growth proceeds to a definite point and stops.

Growth could be particularly troublesome in connection with pistons and cylinder heads that are exposed to elevated temperatures during normal operation and with any other casting where dimensional stability is a factor. By proper heat treatment, however, this growth process may be carried essentially to completion before the castings are placed in service and subsequent growth thus prevented. This treatment consists of artificial aging at relatively low temperatures for comparatively long periods, the temperature and time depending on the particular alloy. Both creep and growth can easily be allowed for in good design, and when proper allowances are made neither is particularly troublesome.

Although some aluminum alloys have a tendency to score or scuff when subjected to mechanical wear, others, notably the piston alloys and the newer bearing alloys, have excellent wear-resisting qualities. The successful functioning of aluminum as a bearing material depends on high hardness and smooth finish of the opposed bearing surface and adequate lubrication.

Most of the aluminum casting alloys are easily welded by any of the common methods. It is thus easy to join aluminum castings to other aluminum parts in composite structures. In addition, it is often possible to repair discontinuities in castings by filling in with weld metal and machining the surface.

Table II—Physical Properties of Aluminum Casting Alloys (Typical Values)

Alloy	Condition[1]					Specific Gravity	Approximate Solidification Range, Deg. F	Thermal Conductivity at 25 C, CGS[2] Units	Coefficient of Thermal Expansion per Deg F x 10^{-6}, 68-212 F	Electrical Conductivity, % of International Annealed Copper Standard
	As Cast	Annealed	Artifically Aged	Solution Heat Treated	Solution Treated and Aged					
C1	—	—	—	S	—	2.81	1195-1020	0.33	12.7	35
C1	—	—	—	—	S	2.81	1195-1020	0.35	12.7	37
CG1	—	S	—	—	—	2.95	1160-1005	0.38	12.2	41
CG1	—	—	—	—	S	2.95	1160-1005	0.31	12.2	33
CG1	P	—	—	—	—	2.95	1160-1005	0.32	12.2	34
CN21	—	S	—	—	—	2.81	1165-995	0.40	12.5	44
CN21	—	—	P	—	—	2.81	1165-995	0.32	12.5	34
CN21	—	—	—	—	P	2.81	1165-995	0.32	12.5	33
CS4	—	—	—	P	—	2.78	1160-980	0.33	12.2	35
CS4	—	—	—	—	P	2.78	1160-980	0.45	12.2	50
CS21	P	—	—	—	—	2.95	1120-940	0.25	11.9	25
CS22	P	—	—	—	—	2.91	1165-975	0.28	12.2	30
CS22	S	—	—	—	—	2.91	1165-975	0.26	12.2	27
CS23	P	—	—	—	—	2.89	1110-930	0.24	—	24
G1	S	—	—	—	—	2.65	1185-1075	0.33	13.3	35
G3	—	—	—	S	—	2.58	1150-840	0.21	13.6	21
GS1	S	—	—	—	—	2.65	1170-1090	0.35	13.0	38
GZ1	P	—	—	—	—	2.65	1180-1050	0.32	13.3	34
S1	S	—	—	—	—	2.69	1175-1070	0.35	12.2	38
S2	S	—	—	—	—	2.69	1175-1070	0.35	12.2	38
S4	D	—	—	—	—	2.69	1175-1070	0.35	12.2	38
S5	D	—	—	—	—	2.66	1085-1065	0.37	11.1	39
S9	D	—	—	—	—	2.66	1085-1065	0.37	11.1	39
SC1	P	—	—	—	—	2.79	1140-960	0.34	11.9	37
SC2	D	—	—	—	—	2.78	1135-970	0.27	11.6	28
SC5	D	—	—	—	—	2.78	1135-970	0.27	11.6	28
SC6	D	—	—	—	—	2.76	1090-970	0.26	11.6	27
SC7	D	—	—	—	—	2.76	1090-970	0.26	11.6	27
SC8	S	—	—	—	—	2.77	1120-950	0.27	—	27
SC8	P	—	—	—	—	2.77	1120-950	0.28	—	29
SC21	—	—	S	—	—	2.70	1160-1075	0.40	12.2	43
SC21	—	—	—	—	S	2.70	1160-1075	0.34	12.2	36
SC21	—	—	—	—	P	2.70	1160-1070	0.36	—	39
SC41	P	—	—	—	—	2.68	1060-1055	0.26	11.2	28
SC42	S	—	—	—	—	2.68	1110-1055	0.27	11.9	29
SG1	—	—	S	—	—	2.68	1130-1075	0.40	11.9	43
SG1	—	—	—	—	S	2.68	1130-1075	0.36	11.9	39
SG1	—	—	—	—	P	2.68	1130-1075	0.38	11.9	41
SG2	D	—	—	—	—	2.68	1095-1050	0.35	—	37
SG3	D	—	—	—	—	2.68	1095-1050	0.35	—	37
SN41	—	—	P	—	—	2.72	1095-1000	0.28	10.5	29
ZG41	S	—	—	—	—	2.80	—	—	13.7	25

[1] *In these columns S denotes specimen cast in green sand; P denotes chill-cast specimen having properties similar to a permanent or semi-permanent mold casting; D denotes die cast specimen.*

[2] *CGS units—calories per sec. per sq. centimeter per centimeter of thickness per deg. centigrade.*

Because aluminum is so high in the electrochemical series it is subject to galvanic attack if joined to most of the other metals, such as copper and steel, in the presence of an electrolyte. This accounts for some of the severe corrosion that has been reported in marine applications, sea water being an excellent electrolyte. Extensive tests, however, have shown some aluminum alloys to have excellent resistance to corrosion by sea water where contacts with other metals are avoided.

Table III—Mechanical Properties of Aluminum Casting Alloys (Typical Values)

Alloy	Condition[1]					Tension[3]			Compression[6]	Hardness[3]	Shear	Fatigue
	As-Cast	Annealed	Artificially Aged	Solution Heat Treated	Solution Treated and Aged	Yield Strength[4] (Set = 0.2%) Psi.	Ultimate Strength Psi.	Elongation, % in 2 In.	Yield Strength[4] (Set = 0.2%) Psi.	Brinell, 500-Kg. Load, 10-Mm. Ball	Shearing Strength, Psi.	Endurance Limit,[5] Psi.
C1	—	—	—	S	—	16,000	32,000	8.5	16,000	60	24,000	6,000
C1	—	—	—	—	S	30,000	40,000	2.0	38,000	95	31,000	7,000
CG1	—	S	—	—	—	20,000	27,000	1.0	20,000	80	21,000	9,500
CG1	—	—	—	—	S	30,000	40,000	0.5	43,000	115	29,000	8,500
CG1	—	—	P	—	—	35,000	37,000	0.5	40,000	115	27,000	8,500
CG1	—	—	—	—	P	36,000	48,000	0.5	36,000	140	30,000	9,000
CN21	—	S	—	—	—	18,000	27,000	1.0	18,000	70	21,000	6,500
CN21	—	—	—	—	S	25,000	28,000	2.0	—	75	24,000	9,500
CN21	—	—	P	—	—	34,000	40,000	1.0	34,000	105	26,000	10,500
CN21	—	—	—	—	P	42,000	47,000	0.5	46,000	110	31,000	9,500
CS4	—	—	—	P	—	22,000	37,000	9.0	22,000	75	30,000	9,500
CS4	—	—	—	—	P	26,000	40,000	5.0	26,000	90	32,000	10,000
CS4	—	—	—	—	P	20,000	39,000	4.5	20,000	80	—	—
CS21	P	—	—	—	—	24,000	32,000	1.5	32,000	100	22,000	—
CS22	S	—	—	—	—	15,000	24,000	1.5	17,000	70	20,000	9,000
CS22	P	—	—	—	—	19,000	28,000	2.0	19,000	70	23,000	—
CS23	—	—	P	—	—	16,000	29,000	1.0	16,000	95	22,000	—
G1	S	—	—	—	—	12,000	25,000	9.0	12,000	50	20,000	5,500
G3	—	—	—	S	—	25,000	46,000	14.0	26,000	75	33,000	7,000
GS1	S	—	—	—	—	13,000	20,000	2.0	15,000	50	17,000	—
GZ1	P	—	—	—	—	16,000	27,000	7.0	17,000	60	22,000	—
S1	S	—	—	—	—	9,000	19,000	6.0	10,000	40	14,000	6,500
S2	S	—	—	—	—	9,000	19,000	6.0	10,000	40	14,000	6,500
S1	P	—	—	—	—	9,000	24,000	9.0	9,000	45	18,000	—
S2	P	—	—	—	—	9,000	24,000	9.0	9,000	45	18,000	—
S4	D	—	—	—	—	14,000	30,000	5.0	14,000	—	—	17,000
S5	D	—	—	—	—	18,000	37,000	1.8	18,000	—	—	19,000
S9	D	—	—	—	—	16,000	35,000	3.5	16,000	—	—	—
SC1	P	—	—	—	—	16,000	28,000	2.0	16,000	70	25,000	—
SC2	D	—	—	—	—	22,000	38,000	2.5	22,000	—	—	22,000
SC5	D	—	—	—	—	—	35,000	3.0	—	—	—	—
SC6	D	—	—	—	—	23,000	42,000	4.0	23,000	—	—	19,000
SC7	D	—	—	—	—	25,000	45,000	2.0	25,000	—	—	20,000
SC8	S	—	—	—	—	18,000	27,000	2.0	18,000	70	—	10,000
SC8	—	—	—	—	S	24,000	36,000	2.0	24,000	80	—	10,000
SC8	P	—	—	—	—	19,000	34,000	2.5	19,000	85	24,000	—
SC8	—	—	—	—	P	27,000	40,000	3.0	27,000	95	—	—
SC21	—	—	S	—	—	23,000	28,000	1.5	24,000	65	22,000	7,000
SC21	—	—	—	—	S	25,000	35,000	2.5	29,000	80	30,000	8,500
SC21	—	—	—	—	S	29,000	35,000	1.5	—	75	—	10,000
SC21	—	—	—	—	P	27,000	43,000	4.0	27,000	90	30,000	9,000
SC41	—	—	—	P	—	27,000	41,000	2.5	27,000	90	—	—
SC41	—	—	P	—	—	26,000	40,000	0.3	26,000	97	—	—
SC41	—	—	—	—	P	38,000	43,000	1.0	38,000	92	—	—
SC42	—	—	—	—	P	40,000	49,000	3.0	—	97	—	—
SC42	—	—	—	S	—	20,000	33,000	2.9	20,000	82	—	—
SC42	—	—	—	—	S	28,000	36,000	2.0	28,000	81	—	—
SG1	—	—	S	—	—	20,000	25,000	2.0	22,000	60	18,000	7,500
SG1	—	—	—	—	S	24,000	33,000	4.0	24,000	70	27,000	8,000
SG1	—	—	—	—	P	27,000	40,000	5.0	24,000	90	—	—
SG2	D	—	—	—	—	20,000	40,000	4.5	20,000	—	—	18,000
SG3	D	—	—	—	—	23,000	42,000	1.8	23,000	—	—	19,000
SN41	—	—	P	—	—	28,000	36,000	0.5	28,000	105	24,000	—
SN41	—	—	—	—	P	43,000	47,000	0.5	43,000	125	27,000	—
ZG41	—	—	S[2]	—	—	25,000	32,000	3.0	25,000	75	26,000	9,000

[1] *In these columns S denotes specimen cast in green sand; P denotes chill-cast specimen having properties similar to a permanent or semi-permanent mold casting; D denotes die cast specimen.*

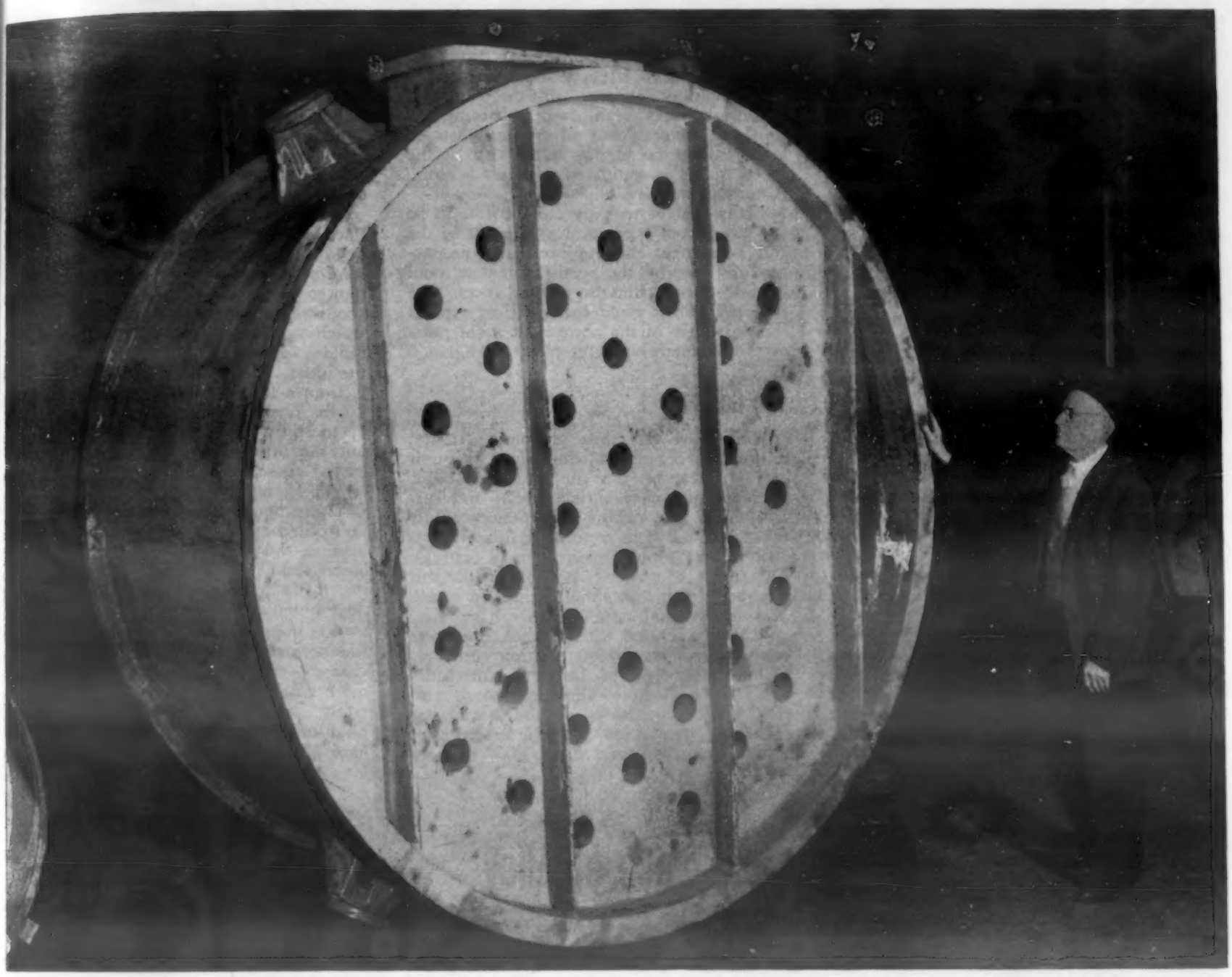
[2] *May be aged at room temperature, or artificially aged at higher temperature.*

[3] *Tension and hardness values determined from standard half-in. dia. specimens individually cast in sand (S) and permanent (P) molds, and tested without machining off the surface. Tension values for die casting alloys determined from standard ¼-in. die cast specimens (D); hardness values are not shown for die castings because they cannot be reliably determined.*

[4] *Yield strength is the stress which produces a permanent set of 0.2% of the initial gage length (Am. Soc. Testing Materials Standard Methods of Tension Testing-E8-46).*

[5] *Endurance limits are based on 500,000,000 cycles of completely reversed stress using the R. R. Moore type of machine and specimen.*

[6] *Compression tests made on specimens having an l/r ratio of 12.*



This 3000-lb. aluminum casting was made for use in a chemical plant. Alloy S1 was found to be well suited to the application because of its high corrosion resistance.

Choice of Casting Method

Before an alloy can be chosen for any specific casting, the method by which the castings are to be produced must first be determined. This involves both functional and economic considerations. The size and shape of the casting, minimum sectional thickness, dimensional tolerances, and surface finish are the primary functional factors to be considered in making this choice; the number of pieces to be cast and the relative machining and finishing costs are the primary economic factors.

The three principal methods of producing aluminum alloy castings are the (1) sand, (2) permanent mold (including semi-permanent mold) and (3) die casting processes. Sand castings account for about 40% of current aluminum casting production; permanent mold castings (including semi-permanent) another 40%; and die castings the remaining 20%. These percentages reflect the trend toward increasing production of permanent mold castings, as that process accounted for less than 20% of the total before the war. Sand castings comprised more than 60% of the prewar total and die castings less than 20%.

Sand Casting

In sand casting, the pattern is molded in sand, as with other metals, the mold being broken to extract the casting and the pattern being remolded for each unit produced. In permanent mold casting, the metal is poured in cast iron or steel molds which are so constructed that the mold may be opened and the casting removed. For full permanent mold castings, the cores are also made of cast iron or steel. The semi-permanent mold method differs from the full permanent mold process only in the substitution of sand cores for the metal cores. Die castings also are produced in metal molds, or dies; but whereas in permanent mold casting the metal flows into the mold cavity by gravity, in die casting it is forced into the cavity under pressure. Both the dies and cores are constructed of heat treated alloy steel.

Sand casting is the most flexible of the three methods and is generally employed for large or intricate castings and for castings of all types and sizes where the

quantity to be produced will not justify the construction of a metal mold or die. Sand casting also is used for longer production runs of small and medium-sized parts of a design suitable to modern high-speed molding equipment where costs lower than for other methods can be established.

Permanent Mold Casting

Both permanent-mold and die-casting processes are inherently mass-production methods. They are, therefore, particularly useful where large numbers of identical castings are to be produced. A permanent mold and its arrangement of gates and risers is not subject to alteration after the mold has been constructed, except at considerable expense. Likewise, a die cannot readily be altered once it has been completed and heat treated. Therefore, it is important that the engineer designing parts for production by these methods have a clear comprehension of the mechanics of the processes. Consultation between the designer, mold or die maker, and foundryman is especially important here to be sure that no important point is overlooked.

Permanent mold castings have higher mechanical properties, greater uniformity, smoother surfaces, closer dimensional tolerances, and better pressure tightness than sand castings. The higher mechanical properties result from the finer grain structure developed by the higher rate of solidification in metal molds. Greater uniformity means that a lower factor of safety may be permissible in calculating the design stresses. By taking full advantage of these factors, castings made by the permanent mold method will require less metal for the same design stress than sand castings. The smoother surfaces and closer dimensional tolerances mean lower machining and finishing costs. These advantages offset to some extent the higher initial cost of the metal mold, as compared with sand-casting pattern equipment.

Many designs that are too intricate to be produced from a practical standpoint by the full permanent mold process can be successfully cast by the semi-permanent mold method through the use of sand cores. The semi-permanent mold method thus extends the flexibility of the permanent mold process while retaining most of its advantages.

Die Castings

Ability to cast thin sections, accuracy, uniformity of reproduction, and low unit cost characterize the die casting process. In reproduction of surface detail and surface finish, die casting is superior to any other method. Die castings compare favorably in cost with permanent mold castings. The thinner sections possible with this method permit substantial savings in metal. The dimensional accuracy, smooth surfaces, and ability to cast threads and core holes contribute to minimum finishing cost.

Two basic types of die casting machines are in use—the so-called gooseneck and cold-chamber machines. In the former, air pressures up to about 750 psi. are utilized; pressures ranging from about 3,000 to more than 20,000 psi., produced hydraulically, are employed in the cold-chamber machine. The higher pressures exert a compacting action upon the metal as long as it remains in the plastic state, which results in a denser metal structure. Because of the superiority of the castings thus produced, the gooseneck machines are gradually disappearing in favor of the cold-chamber units.

Sand castings weighing from a few ounces up to 500 lb. are commonly produced and castings up to 7,000 lb. have been made by this process. Permanent and semi-permanent mold castings from a few ounces to 50 lb. in weight are in regular production, but permanent mold castings weighing up to 250 lb. and semi-permanent mold castings up to 500 lb. have been produced. For die castings the weight range is from a fraction of an ounce up to about 20 lb. Castings having over-all dimensions up to 36 by 12 by 9 in. are being produced, but the dimensions in one direction may exceed these, die castings up to 84 in. in length having been produced.

The importance of close collaboration between the casting user and the foundryman in this consideration cannot be overemphasized, as the most appropriate casting method for many designs can best be determined on the basis of experience with similar designs. In addition, an experienced foundryman often can suggest design changes that will result in simpler and more economical production. More importantly, such changes usually promote the production of sounder castings that will have an increased service life.

Choice of Alloy

After the casting method best suited to the design and production requirements has been determined, an alloy suitable for that method which will have the necessary properties may be chosen. Sometimes it is difficult to find an alloy that will ideally have all the desired characteristics. Usually the final choice will narrow down to the alloy representing the best compromise between two or more conflicting factors.

The first decision to be made is whether one of the alloys not requiring heat treatment will provide the necessary mechanical and other properties, or whether one of the heat treated alloys will be required. As shown in Table III, heat treatment increases the strength, but usually lowers ductility. Although tensile strength is perhaps the most significant single characteristic to be considered, an alloy should not be chosen on the basis of that property alone. Yield strength, elongation, hardness, and compressive, shear and fatigue strengths are other mechanical characteristics that may be significant in any particular application.

Attention must also be given to the casting qualities. For simple designs where high strength is not a factor, the casting qualities do not require any special consideration; but if the design is complicated or if the castings must be pressure tight, an alloy having good casting qualities should be used. In general, alloys having difficult casting characteristics are required. With complex designs it becomes necessary to use the best casting alloy and to supply the necessary properties to the casting by increased section thickness. This is most true in permanent mold and die castings.

If the castings will be exposed to corrosive elements such as acids or salt water in service, then one of the alloys having high resistance to corrosion should be used. Machinability is another characteristic that should receive careful consideration for castings requiring considerable machining. While ease of machining and finishing is one of the outstanding characteristics of aluminum castings in general, some alloys machine easier than others.

Where the castings must retain their strength at elevated temperatures, such as those used in internal-combustion engines, one of the alloys possessing this characteristic must be used. Some engine parts require good resistance to wear in addition to high strength at elevated temperatures. Pistons, for example, require this combination of properties plus good casting and machining characteristics and low coefficient of thermal expansion.

In applying the values given in Table III to an actual design, it must be borne in mind that those values are based upon tests made on carefully cast test bars. In some castings these characteristics may not be fully realized. For example, in castings involving thick sections where the rate of solidification of the metal is relatively slow, the unit mechanical strength will be lower than that shown by the test bars. Likewise, in castings having thinner sections the unit mechanical strength may be higher than in the separately cast test bars. Also, in castings having thinner sections the unit mechanical strength may be higher than in the separately cast test bars.

For the same reasons, test bars machined from different parts of the same casting may show different mechanical properties, depending on the location from which they were taken. Section thickness and any foundry or other variables influencing the solidification rate of the metal will affect the mechanical properties of the casting.

Selection of an alloy for any given casting thus involves (1) consideration of foundry characteristics and physical properties, and (2) the determination of the proper factor to be applied to the specified mechanical properties in calculating the design stress. In determining this factor the class of service for which the casting is intended must be taken into consideration as well as variations in the properties of different sections. There are no hard and fast rules by which such factors can be determined and applied; good judgment based on sound experience is the best guide.

Outstanding characteristics and some typical applications of commercial aluminum alloys are listed in Table IV. By

Table IV—Outstanding Characteristics and Some Typical Applications of Cast Aluminum Alloys

Alloy	Corrosion Resistance	Casting Properties	Machinability	Outstanding Characteristics	Typical Applications[1]
C1	Good	Good	Very good	Good combination of mechanical properties.	(S) General, where high strength and ductility are required—flywheel housings, bus wheels, spring hangers, aircraft wheels and fittings, crankcases.
CG1	Fair	Good	Excellent	Good strength and hardness at elevated temperatures. Good wear resistance.	(S&P) Air-cooled cylinder heads, bearings, bearing caps, bushings, tappet guides, automotive pistons, meter parts.
CN21	Good	Fair	Very good	Good strength at elevated temperatures.	(S&P) Air-cooled cylinder heads, motorcycle, Diesel, and aircraft pistons, aircraft generator housings.
CS4	Good	Good	Good	Good combination of mechanical properties. Good weldability.	(P) General, where high strength and ductility are required—aircraft fittings, wheels, and gear housings, railroad-car seat frames, compressor connecting rods, fuel-pump bodies.
CS21	Fair	Good	Very good	High hardness as cast; retained at elevated temperatures.	(P) Sole plates for electric hand irons.
CS22	Fair	Very good	Excellent	Good general-purpose alloy. Good pressure tightness.	(S&P) Automotive cylinder heads, crankcases, oil pans, transmission cases, washing-machine agitators, vacuum-cleaner housings, miscellaneous general-purpose castings.
CS23	Fair	Good	Good	High hardness; retained at elevated temperatures.	(P) Pistons and other high-hardness applications.
G1	Excellent	Fair	Very good	High corrosion resistance and good mechanical properties.	(S) Dairy and food-handling equipment, cooking utensils, fittings for marine, chemical, and sewage use, ornamental housings.
G3	Excellent	Fair	Very good	Highest strength and elongation of any sand casting alloy.	(S) High-strength structural castings—aircraft fittings, levers, brackets, railroad passenger-car frames. Not recommended where operating temperatures exceed 250 F.
GS1	Excellent	Fair	Excellent	High corrosion resistance.	(S&P) Cooking utensils and pipe fittings for marine and general use. Ornamental hardware and architectural castings.
GZ1	Excellent	Fair	Excellent	High corrosion and tarnish resistance.	(P) Cooking utensils and castings to resist atmospheric corrosion.
S1	Very good	Very good	Fair	High corrosion resistance and pressure tightness.	(S&P) Carburetor bodies, refrigerator fittings, cooking utensils, marine fittings, food-handling equipment, architectural and ornamental parts.
S2	Good	Very good	Fair	Same as S1 except lower corrosion resistance.	(S&P) Same as S1 where the higher corrosion resistance is not required.
S4	Good	Very good	Fair	Same as S2.	(D) General-purpose castings with thin sections—carburetor bodies, refrigerator fittings, outboard-engine parts, marine fittings.
S5	Very good	Excellent	Fair	Good mechanical properties with excellent castability.	(D) General-purpose castings of intricate design with thin sections, or with both thin and heavy sections—typewriter frames, outboard-engine pistons, dental equipment, instrument cases.
S9	Very good	Excellent	Fair	Same as S5, but lower impurities.	(D) Same general applications as S5, but where higher elongation is required.
SC1	Fair	Excellent	Good	Good pressure tightness and weldability.	(P) Ornamental grilles, reflectors, and general-purpose castings requiring leak tightness and moderate strength.
SC2	Fair	Good	Good	Good combination of strength and ductility.	(D) Simple castings without very thin walls. Brackets, frames, and levers with thick sections.
SC5	Fair	Good	Good	Same as SC2, but lower impurities.	(D) Same general applications as SC2, but where higher elongation is required.
SC6	Fair	Very good	Good	Same as SC7, but lower impurities.	(D) Same general applications as SC7, but where higher elongation is required.
SC7	Fair	Very good	Good	Good casting and mechanical properties.	(D) General-purpose castings; will cast satisfactorily in thinner sections than SC2 or SC5.
SC8	Fair	Good	Good	Good general-purpose alloy.	(S&P) General-purpose castings—piano plates and frames, gasoline and oil tanks, crankcases, typewriter frames, engine parts, water-cooled cylinder heads.
SC21	Good	Excellent	Good	Good pressure tightness and weldability. Retains strength at elevated temperatures.	(S&P) Wide variety of aircraft uses requiring pressure tightness and intricate high-strength castings, printing press bed plates.
SC41	Good	Fair	Fair	Good hardness and wear resistance at elevated temperatures.	(P) Pistons.
SC42	Good	Excellent	Good	Retains strength at moderately elevated temperatures.	(S) Wide variety of aircraft castings and intricate high-strength castings.
SG1	Excellent	Excellent	Good	High strength and pressure tightness. Good weldability.	(S&P) General, where high-strength and corrosion resistance are required, particularly in automotive field, machine-tool parts, hand wheels, aircraft-pump parts.
SG2	Excellent	Excellent	Good	Same as SG3, but lower impurities.	(D) Same as SG3, but where higher elongation is required.
SG3	Excellent	Excellent	Good	Good casting and mechanical properties, and corrosion resistance.	(D) General-purpose castings requiring high resistance to corrosion. Cover plates, instrument cases.
SN41	Good	Fair	Fair	Good properties at temperatures up to 500-600 F. Low coefficient of thermal expansion. Good weldability.	(P) Pulleys and sheaves, automotive and Diesel pistons.
ZG41	Good	Good	Excellent	Good physical properties obtained by aging.	(S) General, where high strength and ductility are required without heat treatment.

[1] *In these columns, S, P and D designate, respectively, sand, permanent mold (including semi-permanent), and die castings.*

Table V—Classification of Aluminum Casting Alloys by Type of Application

Class	Casting Method		
	Sand	Permanent Mold	Die
General-purpose alloys	C1 SC8 ZG41	CS4 SC8	SC2 SC5[1] SC6[1] SC7 S4 S5 S9[1]
General-purpose alloys where pressure tightness is required	CS22 S1 SC21 SG1	CS22 S1 SC21 SC1 SG1	—
Alloys for architectural and decorative purposes	S1 G1 GS1 SG1	S1 GS1 GZ1 SG1	—
Alloys with high resistance to corrosion	S1 S2 G1 GS1 G3 SG1	S1 S2 GZ1 SG1	S4 S5 S9[1] SG2[1] SG3
Alloys retaining strength at elevated temperature	CG1 CN21 SC21 SC42	CG1 CN21 SN41 SC21 CS21 SC41	—
Piston alloys	CG1 CN21	CG1 CN21 CS23 SN41 SC41	—

[1] *These die casting alloys suitable for use only in cold-chamber (high-pressure) machines.*

class of application, the alloys may be grouped as shown in Table V.

General-Purpose Alloys

Alloys containing copper and silicon, either singly or together, or in combination with smaller amounts of other elements, comprise the groups that are most widely used for the great bulk of aluminum casting production. In addition, these alloys cover a wide range of mechanical properties so that they are useful as well for some of the more specialized purposes. Typical of this class of alloys are sand casting alloy C1, permanent mold alloy CS4, and alloys CS22 and SC8 for both methods of casting. Alloys C1 and CS4 are greatly benefited by heat treatment and when so treated have excellent combinations of mechanical properties (Table III). Alloy SC8 is one of the most versatile of all the general-purpose alloys, having excellent properties in both the as-cast and heat treated conditions.

The aluminum-copper-silicon alloys, such as SC1 and SC8, have better casting characteristics than the aluminum-copper alloys, but are not as resistant to corrosion as the aluminum-silicon series. The copper content provides strength and hardness while the silicon content improves the casting qualities and increases the resistance to corrosion. These alloys are particularly well adapted to casting work involving intricate design, having large differences in section thickness, or requiring pressure tightness. Excellent casting characteristics also are found in the aluminum-silicon alloys such as S1 and S2, together with higher resistance to corrosion. For these reasons there is an increasing trend toward the use of aluminum alloys in which silicon is a major alloying element. Although the machining of these alloys is more difficult than of many other aluminum alloys, the problem is simplified by proper technique, tools and lubricants.

Pressure tightness, strength, corrosion resistance, and castability in particularly desirable combinations are the outstanding attributes of aluminum-silicon-magnesium alloys SG1 and SC21 (which also contains copper). When heat treated they have tensile properties comparable with those of the 4% copper alloys C1 and CS4. They are outstanding for all types of service requiring high-quality castings, especially those of intricate design.

Sand casting alloy ZG41 is particularly useful where heat treating facilities are not available, as it attains desirable properties by simply aging at room temperature. Although the aluminum-magnesium alloys are especially noted for their corrosion resistance, one alloy, G3, has the highest mechanical properties of any of the commercially used aluminum sand casting alloys. The alloy is difficult to cast, however, and unless special foundry practices are applied in handling it, these extreme mechanical properties may not be realized in the completed castings.

Among the die casting alloys, SC2 is commonly used for general-purpose castings that do not include thin sections. Alloy SC7 is somewhat similar, but its higher silicon content enables it to be cast into thinner sections. The aluminum-silicon alloys S4 and S5 have still better casting characteristics, as well as higher resistance to corrosion. Alloy S4 is widely used for thin-section castings of intricate design, while S5 is particularly adapted to designs including both thin and heavy sections. Alloys SC5, SC6 and S9 are identical with alloys SC2, SC7 and S5, respectively, except that the impurities, notably iron, are controlled to closer limits, which provides higher elongations (Table III). Alloys SC5, SC6 and S9 may be used only in cold-chamber machines, while alloys SC2, SC7, S4 and S5 are suitable for either gooseneck or cold-chamber units.

Architectural and Decorative Alloys

Resistance to atmospheric corrosion and exceptional castability are the two prime requisites for alloys to be suitable for architectural and decorative purposes. The aluminum-silicon and aluminum-magnesium alloys stand highest on the list in corrosion resistance, and the aluminum-silicon series has excellent casting characteristics which enable them to reproduce faithfully fine design details. The aluminum-magnesium series has higher resistance to corrosion than the aluminum-silicon alloys but the casting qualities are not as good. Both types are well adapted to surface finishing of various kinds, particularly the electrolytically produced oxide finish. (Surface finishing is discussed in a subsequent section of this manual.)

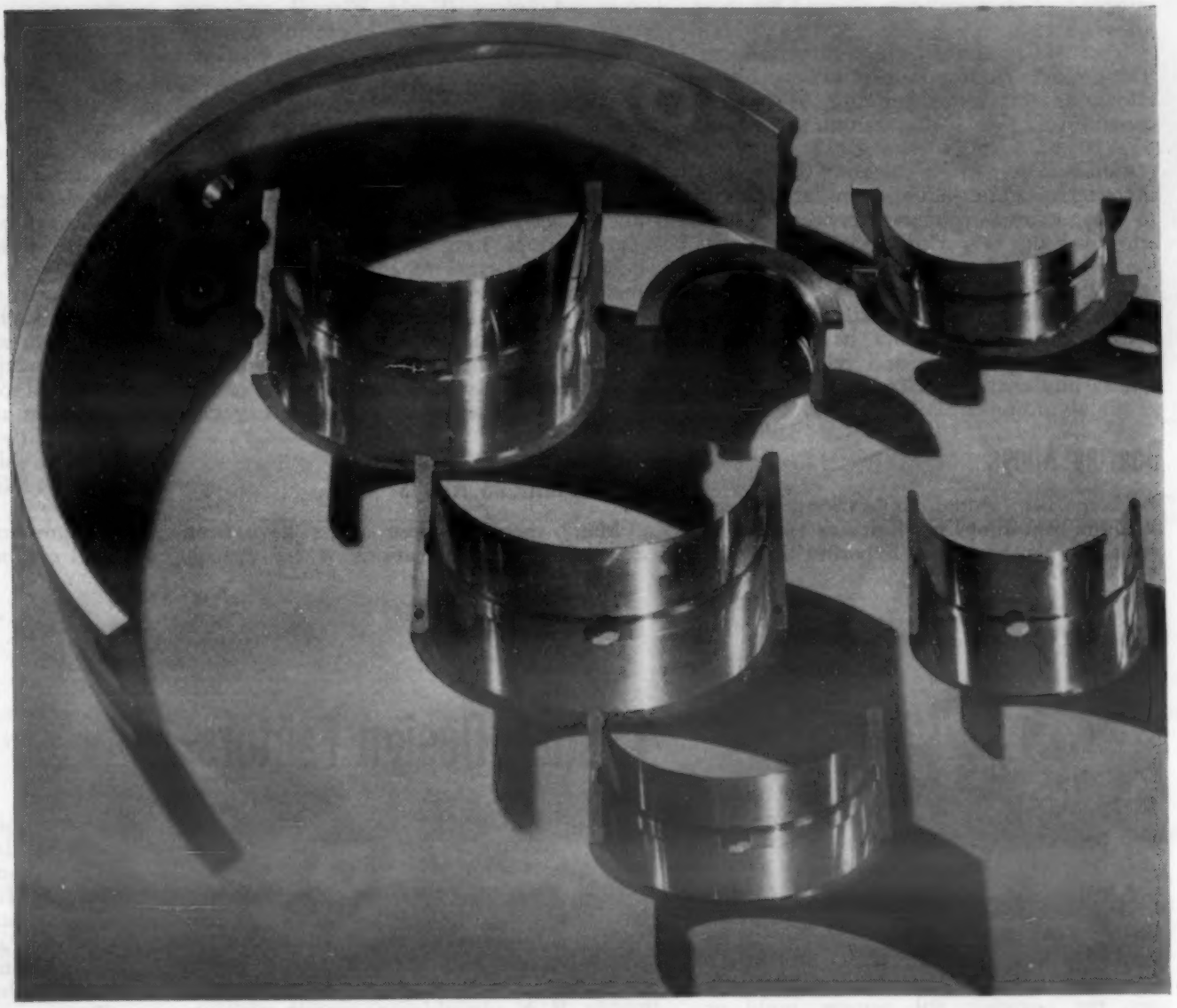
For the majority of architectural uses, including spandrels, plaques, name plates, doors, and ornamental work in general, alloy S1 is excellent. Alloys G1, GS1 and GZ1 also are used extensively, especially where the finish must match the finish of adjacent parts fabricated from some of the wrought aluminum alloys. Where higher strength is required, the heat-treated aluminum-silicon-magnesium alloy SG1 is used.

Alloys Having High Corrosion Resistance

As already indicated, the aluminum-silicon and aluminum-magnesium alloys have the highest resistance to corrosion of any of the aluminum alloys. Other alloys, however, have better resistance to certain types of exposure.

The aluminum-silicon series, notably alloy S1 for sand and permanent mold casting and alloys S5 and S9 for die casting, are widely used in marine work because of their excellent resistance to salt water and salt-laden atmospheres. Although the aluminum-magnesium series is much more corrosion resistant, these alloys are not used so widely because of their difficult casting characteristics. By adding other elements, such as silicon or zinc (GS1 and GZ1), the casting properties are somewhat improved. The aluminum-silicon alloys, however, are superior in mildly acid solutions such as those found in the textile industry. Both series, especially alloys S1 and G1, find extensive applications in the food handling and chemical industries. Where high strength must be combined with high corrosion resistance, aluminum-silicon-magnesium alloy SG1 is excellent, providing good pressure tightness and weldability as well. Die casting alloys SG2 and SG3 are somewhat similar, impurities being more closely controlled in the former.

In severely corrosive environments, oxide surface finishes supplemented by a dichromate impregnation of the oxide film makes these alloys even more resistant to attack. These finishes are discussed in more detail in a subsequent section of this manual.



Aluminum bearings are being more widely applied in industry. Shown are several bearings produced by the permanent mold process.

Alloys for Use at Elevated Temperatures

Pistons, cylinder heads, and other parts of internal-combustion engines are among the most prominent applications requiring maintenance of mechanical properties at elevated temperatures. Alloys CG1, CN21, SN41 and SC21 all retain in relatively high degree their strength and hardness at engine operating temperatures (Table VII). All these alloys are improved by heat treatment, and choice of both alloy and heat treatment depend on the service conditions. Alloy CN21 is used for cylinder heads of air-cooled engines requiring good retention of properties up to temperatures of 500 to 600 F. For crankcases and cylinder heads of liquid-cooled and Diesel engines and other applications involving temperatures upwards of 400 F, alloy SC21 has been found to be especially suitable.

In addition to the requirement for retaining their mechanical properties at elevated temperatures, alloys to be suitable for use in pistons of internal-combustion engines must have good wear resistance, low coefficient of thermal expansion, and good casting qualities. Alloy CG1 has been widely used for this purpose in the past but has been largely replaced by alloys CN21, CS23, SC41 and SN41. Alloy CN21, also known as "Y" alloy, has some of the characteristics of the aluminum-magnesium alloys; it is suitable for both sand and permanent mold castings, but when used in permanent mold work special precautions must be taken to keep the castings free from dross and defects. Aluminum-copper-silicon alloys of the CS23 type also are used in the permanent mold production of pistons.

Alloy SN41, containing silicon, nickel, magnesium and copper, has come to be used extensively for the production of pistons by either permanent or semi-permanent mold methods. Alloy SC41 is similar except that it contains manganese instead of nickel. A modification of alloy SN41, known as Alcoa alloy D132, has been recently introduced by the Aluminum Co. of America for piston applications. Improved casting characteristics are claimed for this alloy, which has a nominal composition in per cent, as follows (balance aluminum): 8.5 to 10.5 silicon, 2.0 to 4.0 copper, 0.5 to 1.5 magnesium, 0.5 to 1.5% nickel. These alloys have the lowest coefficients of thermal expansion of the group and retain their strength well at operating temperatures.

Alloy SC41 under normal conditions should prove to be slightly less expensive than SN41. Likewise, alloy SC42 is a less expensive alternate for alloys SC21 and SG1. It has somewhat similar characteristics and is used mostly for the parts of internal-combustion engines. It has good casting characteristics and retains its strength well at moderately elevated temperatures.

The Ternalloys and Almag Alloys

Among the more important alloys recently introduced and not yet included in the ASTM specifications are the Ternalloys developed by the National Smelting & Refining Co. and the Almag alloys developed by the Cooper Metallurgical Laboratories of Acme Aluminum Alloys, Inc.

The Ternalloys are aluminum-magnesium-zinc alloys similar in some respects to ASTM alloy ZG41. Three alloys have been developed having magnesium content of 1.6 to 2.0, 1.8 to 2.4, and 2.0 to 2.6%, and zinc content of 3.4 to 2.9, 4.0 to 4.5, and 4.6 to 5.1%, respectively. Compared with alloy ZG41, therefore, the magnesium content of the Ternalloys is higher and the zinc content lower. Like alloy ZG41, all three alloys need only be aged at room temperature to provide good mechanical properties although artificial aging treatments are used in some cases to advantage. All three alloys are said to be suitable for both sand and permanent mold casting, although it is expected that their casting characteristics are inferior to those of some of the older alloys. Tensile strengths range from 35,000 psi. for sand castings to 44,000 to 50,000 psi. for permanent mold castings. High dimensional stability is one of the

outstanding characteristics claimed for these alloys.

Two Almag alloys have been introduced. These are aluminum-magnesium binary alloys, as the name indicates, Almag 35 containing 6 to 8% magnesium, and Almag 55, 10 to 11.5%. Almag 55 thus corresponds closely to ASTM alloy G3, and its characteristics are therefore similar. Midway in magnesium content between ASTM alloys G1 and G3, Almag 35 has properties somewhat different from either. Tensile strength is of the order of 35,000 psi. It is said to be suitable for all casting processes. Both Almag alloys have the high resistance to corrosion and relatively difficult casting characteristics that are common to all aluminum-magnesium alloys.

Bearing Alloys

Except for limited applications, the use of aluminum alloys for bearings is of comparatively recent origin. Experimental work initiated before World War II and continued after the war has led to the development of three casting alloys for bearings, all intended for permanent mold casting and a variety of heat treatments. The first of these alloys contains nominally 6.5 tin, 1.0 copper, and 1.0% nickel; the second is similar except that silicon is added; the third contains higher percentages of copper and nickel with an addition of magnesium. These alloys have high fatigue strength, excellent resistance to corrosion, high thermal conductivity, relatively low hardness, ability to minimize shaft wear, and flexibility. They have been used mostly in heavy-duty service such as connecting-rod, main, and thrust bearings, notably in the Diesel engine field; other uses are expected to follow.

Miscellaneous Alloys

Many special-purpose alloys have been developed for applications where specific characteristics are desired. Their usefulness, however, usually is limited to the particular applications for which they are designed. Typical of these highly specialized alloys is a binary alloy containing 2% manganese which has high resistance to slightly acid solutions and has excellent ductility. It has limited use because of its difficult casting characteristics.

Controlled electrical conductivity is required in some electrical equipment, particularly in the rotor bars of induction motors. In many rotors these bars are cast integral with the collector rings and cooling fans by a special pressure casting process. When maximum conductivity is required, controlled compositions of essentially pure aluminum are used. Where the design permits slightly lower conductivity, the addition of 1.5% silicon materially improves the casting qualities. Where low electrical conductivity is necessary, an alloy containing 6 magnesium, 1.5 manganese and 1.5% nickel can be used.

Casting Design Factors

After the casting method and alloy have been chosen, the full details of design must be considered. In many respects the design of a casting for aluminum alloys is similar to that required for other metals. Special consideration, however, must be given to certain factors if best results are to be obtained. Close cooperation between the user, the engineer, the pattern, mold or die maker, the metallurgist, and the foundryman is necessary if the full potentialities of aluminum alloys are to be realized in the finished castings.

Wherever possible, section thickness should be uniform throughout, especially in permanent mold and die castings. If sections of different thickness cannot be avoided, the thickness should be increased gradually, or blended, where sections of different thickness adjoin. Sections should have a minimum thickness of ⅛ in. for sand and permanent mold castings, although 3/16 in. of thicker sections are required for most castings. Under special conditions, castings having sections thinner than ⅛ in. can be produced in permanent molds. Die castings having a major dimension of 6 in. can be produced with sections as thin as 0.045 in.; larger die castings will require somewhat thicker sections, but thicknesses in excess of 0.15 in. seldom are required by the casting process alone.

Large flat areas should be avoided, as they involve casting difficulties; slightly curved design usually can be substituted. Where added strength is needed, sections may be stiffened by reinforcing ribs which in general should be about 1½ times as thick as the supporting sections. Ribs should have flat rather than rounded edges, to avoid overstressing the outer layers. Beads should be added to the outer edges of ribs wherever this can be done without undue complications. Generous fillets should be provided between ribs and their supporting sections as well as between adjoining sections themselves.

Locating points for the guidance of the machine shop in machining the casting should be so specified with respect to the outside walls of the casting that they will not be affected by core shifts. They should be clearly indicated on the drawings. Special care is required in specifying locating points for castings to be made in permanent molds; it is advisable to consult with an experienced permanent mold foundryman in this matter.

Both draft and shrinkage must be taken into account in the design. In sand casting, sufficient draft, or taper, must be provided on all vertical faces to permit the pattern to be drawn from the mold. At least 1/16 in. per ft. (0.5%) must be allowed, and the drawings should indicate whether this is to be added to or subtracted from the dimensions shown.

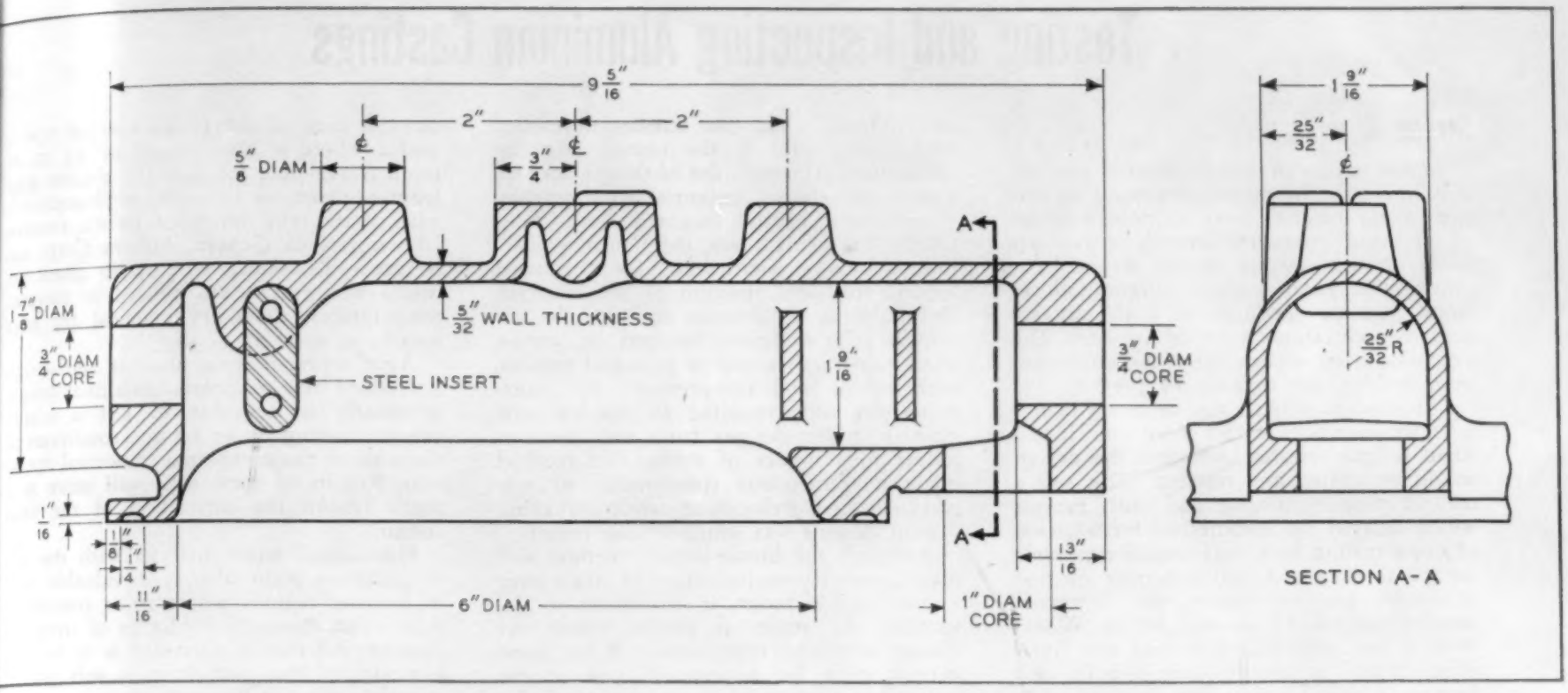
In permanent molds, sufficient draft must be provided on the vertical surfaces to permit the casting to be removed from the mold. This will vary, depending on the orientation of the particular face with respect to the body of the casting. Because the metal has a tendency to shrink away from the outer surfaces of the mold cavity and to shrink tightly around the inner surfaces, more draft is required on the inner than on the outer surfaces. On outer surfaces the draft angle can vary from 1 to 3 deg.; on inner surface it should be 2 deg. minimum, 5 deg. desirable.

As in permanent mold casting, parts designed for die casting must have sufficient draft to enable the castings to be removed from the dies, and the cores must have sufficient draft to permit them to be drawn from the castings. For round holes up to ⅛ in. in dia., the required draft is 0.020 in. per in. of depth; ⅛- to ¼-in. holes, 0.016 in.; and ¼- to 1-in. holes, 0.012 in. For larger openings, 0.012 per in. of depth should be allowed for the first inch of diameter, plus 0.002 in. for each additional inch. On surfaces in square, rectangular or irregular holes, the draft may be the same as for circular holes having diameter equal to the distances between opposite surfaces. Where draft is necessary on outside surfaces, it should be about half that required on inside surfaces. On surfaces against which shrinkage takes place, the draft should be the same as on inside surfaces.

To compensate for the linear shrinkage resulting from the contraction of the molten metal upon solidification and cooling to room temperature, the pattern must be larger than the desired casting. This allowance may vary from 1/10 to 5/32 in. per linear ft., depending on variations in casting design, alloy, and resistance to contraction offered by the mold and cores. Less shrinkage allowance is required with permanent mold and die casting than with sand casting.

Finish allowance necessary on different parts of a casting will vary, depending on the casting process, size of the casting, method of machining, and type of finish. For sand casting, simply rapping the pattern during the molding operation will often provide sufficient allowance where only grinding or filing is required. For small and medium-size castings to be finished in a lathe, planer, or milling machine, ⅛ in. usually is sufficient; ¼ in. or more is required on large castings. Less finish allowance is required in permanent mold castings because of the smoother finish and greater uniformity of dimensions; allowances of 1/32 to 1/16 in. are adequate for small and medium size castings, and up to ⅛ in. for large castings.

Finish allowances on die castings will depend on the use for which the castings are intended. For many purposes the smooth surfaces produced on castings made by this method are satisfactory without any finishing operations beyond removing the fins which usually are formed at parting lines. In other cases, polishing operations are required and allowances approaching



These sectional views of a typical small aluminum casting (2 lb.) show the application of design principles. Note generous fillets, blending where section thickness changes, reinforcing ribs, and core specifications. Dimensions shown are final.

those specified for permanent mold castings may be necessary. Machining of die castings should be held to a minimum, as too much machining may remove the tough dense surface layer which is characteristic of castings produced by this process. Therefore, machining allowances in die cast designs should be held to a minimum.

For all types of castings the design should permit mold parting lines to be straight wherever possible, as uneven parting lines usually will result in higher production costs. Deep pockets and small recesses should be avoided in order to simplify the design of the required cores. Undercuts are troublesome and should also be avoided whenever possible.

It is highly advantageous to design parts for sand casting so that any necessary cores are formed as part of the mold. When separate cores are required, they should be kept as simple as possible. Long thin cores should be avoided wherever possible, because of the danger of breakage. A design requiring two-piece or multiple cores resulting in fins also should be avoided, especially if the fins cannot be removed.

Core prints in designs for sand and semi-permanent mold casting must be large enough to allow the escape of gases developed during the pouring operation and to permit removal of any chills or strengthening wires used in the cores. In castings that must be pressure tight, additional core prints beyond those normally required for core support may be necessary for the escape of mold gases. Any openings in casting walls made by core prints that are not required for functional purposes may be closed by a threaded plug, a welded or bolted plate, or other means. Where core prints are necessary in highly stressed sections, a bead around the hold will compensate for the loss of section.

In permanent mold casting, the metal cores are withdrawn from outside the mold before the casting is removed. Complicated parts may require the use of sand cores (semi-permanent mold method) or split cores and multiple-piece molds. These are more expensive and require more production time than simple cores and two-piece molds, and often design changes can be made to simplify both the mold design and the coring. Interlocking metal cores should never be used in permanent mold casting.

Cores should be specified wherever possible in die casting designs, as their use will promote structural soundness, insure uniform section thickness, and save metal. As in the other methods of casting, the simpler the cores can be the better. The simplest designs will require only cores that are parallel to the direction of the die motion; such cores may be permanently fixed in either half of the die. Long cores should be avoided unless they can be piloted into the opposite section of the die. Cores that are not parallel to the direction of motion of the die and interlocking cores introduce complications and therefore should be avoided insofar as the design will permit.

Hard metal inserts often are used in aluminum castings at points subject to excessive wear or stress. These are usually cast iron or steel, but copper or brass may be used if properly protected to prevent their solution in the molten aluminum. Keyed inserts sometimes are used where high torque must be transmitted to a rotating aluminum part. Sufficient metal must be provided around inserts to prevent cracks from contraction stresses during solidification. Inserts should be knurled, grooved, or keyed so as to provide good mechanical retention under service conditions. Large inserts may be slotted where contraction stresses must be held to a minimum.

The heating elements of electric irons and hotplates are often cast in place, providing better heat distribution and faster heating than could be obtained with separate heating elements. Small-diameter copper tubing also can be cast into the walls of aluminum castings, providing passages for oil or other fluids, which could not be cast or machined because of their small diameter or curved direction.

Dimensional Tolerances of Permanent Mold and Die Castings

Dimensional tolerances can be held much closer in permanent mold than in sand castings, ranging from 0.02 to 0.05 in. On medium-sized castings without many parting lines, it is possible to hold within minus 0.01 to plus 0.02 in. across parting lines. Across fixed portions of the mold cavity, tolerances can be held to plus or minus 0.01 in. Straight cored holes may be held within plus 0.005 in. to minus 0.01 in. in dia. Minimum diameter of cored holes is ¼ in.

In die castings dimensional tolerances can be held even closer than in permanent mold castings. On close dimensions, minimum tolerance is plus or minus 0.0015 in. per linear in., but not less than plus or minus 0.002 on any dimension. Fractional dimensions up to 7 in. have a tolerance of 0.010 in. Dimensions up to 7 in. have a tolerance of 0.010 in. Dimensions affected by the parting line or other moving parts of the die have an additional tolerance which sometimes is as much as 0.010 in. The flatness tolerance of die castings can be determined approximately by multiplying the longest dimension by 0.0015.

Designers should not specify closer tolerances than necessary or close tolerances at too many points on a casting. Draft angles and allowances also should be held to the specified ranges. Exceptionally close tolerances and extremely small draft angles can be had only at higher cost and decreased production.

Testing and Inspecting Aluminum Castings

Stress Analysis

In the design of highly stressed castings it is important for most economical utilization of the metal to make a careful analysis of expected operating stresses in various parts of the castings under service conditions. To guard against fatigue failures from repeated loadings at high stresses, stress concentrations must be avoided. The exact locations where these concentrations may develop are difficult to predict.

Until recent years it was necessary to test new designs under service conditions. If and when fatigue failure developed, the design would be altered and retested. This was a tedious, time-consuming, and costly process which delayed the commercial introduction of a new casting for a considerable time after its initial design. A brittle-lacquer method of stress analysis called the Stresscoat method introduced shortly before World War II has materially remedied this situation. When a casting coated with this lacquer is loaded, cracks that develop in the lacquer give a direct indication of the strain, from which the stresses developed in various parts of the casting may be determined. The closeness of these cracks indicates the relative concentration of stresses.

Although brittle lacquers have been known for many years, their primary usefulness was in indicating areas stressed beyond the yield strength of the material. Development of Stresscoat extended the usefulness of the brittle lacquers by giving quantitative indications of principal stresses, both tensile and compressive. By shortening the time required to develop new aircraft engine designs from two years or longer to a matter of weeks, this method made a tremendous contribution to war production. Development work on other casting designs was similarly accelerated.

Although the brittle-lacquer method will give a quantitative indication of strain over a considerable range, it is difficult to determine the strain at points where the stresses are highly concentrated. When these stresses must be determined, one of the well known types of strain gages can be used. For measurements at room temperatures, a gage of the Huggenberger type is useful where a gage length of ½ in. or more is available for test. For shorter gage lengths, down to 1/16 in., a photoelectric gage of the type developed by the research laboratories of General Motors Corp. can be used. Resistance wire strain gages are useful where tests are desired at elevated temperatures; these are practical for gage lengths as short as ¼ in.

After repeated stress analysis and design alterations have culminated in a final design, it usually is desirable to test a highly stressed casting under service conditions at loads above those expected in normal operation. Results of these tests will serve as a check against the correctness of the final design.

Photoelastic stress analysis with the aid of polarized light also is a valuable tool in locating regions where stress concentrations exist, especially in forms of irregular contour. All that is necessary is to fashion a model of the part from a soft plastic material. After it hardens, stress is applied and examination made by means of polarized light. Visual observation will show the locations of maximum stress. When design changes are made it is only necessary to fashion a new model, or alter the previous one, after which a second examination can be made.

The photoelastic method of analysis is said to yield results in close agreement with the mathematical theory of elasticity. Since the development of Polaroid some years ago, the cost of equipment required for this method has been brought within reach of even small design offices and laboratories.



In the illustrated finishing operation, the workman is wire-brushing a cast aluminum alloy mandrel.

X-Ray Examination in Casting Design

X-ray examination proved of inestimable value in the inspection of aluminum aircraft and other castings during the recent war. It will prove equally useful in maintaining the quality of castings for peacetime uses. Development of the proper design, and establishment of proper foundry procedures also are facilitated by X-ray examination.

One of the larger aircraft companies recently made a thorough study of its program of inspection by X-ray and other methods. Up to that time X-ray inspection had been used primarily as a tool in large-scale routine inspection, with improvement of the parts through correction of any defects revealed by such inspection more of a secondary function. After studying various aspects of the problem, it was decided that this relative emphasis should be reversed. Therefore, future work was based on the premise that the primary purpose of X-ray inspection was to serve as a creative means for improving the quality of castings by changes in the design where this appeared to be necessary, by correction of faulty foundry technique, and by improvement in pattern or mold equipment.

Thorough X-ray inspection of the initial castings of a new design will indicate when changes in the casting design, in the arrangement of gates and risers, or in foundry procedure are necessary or desirable for the consistent production of sound castings.



Often sand-blasting is used to finish cast aluminum parts, as is the case with this architectural part.

Processing Aluminum Alloy Castings

Heat Treatment

Many aluminum alloys are used in their as-cast condition, their properties being entirely adequate for the applications to which they are best adapted. Other alloys depend on heat treatment for the development of their optimum properties; this is especially true of many high-strength and special-purpose alloys. Both sand and permanent mold castings are heat-treated. Die castings, however, because of their inherent internal porosity, are seldom heat treated, as the entrapped air and gases usually expand and raise surface blisters at heat treating temperatures.

Three basic types of heat treatment are given:

1. Artificial aging.
2. Solution heat treatment.
3. Solution treatment followed by artificial aging.

As the name implies, artificial aging involves holding the castings to be treated at an intermediate temperature for a certain length of time. Both time and temperature are adjusted to affect the desired change in properties. This varies from a simple anneal to a stabilizing treatment which consummates during heat treatment most of the growth, or permanent increase in linear dimensions, of the castings that otherwise would take place in service.

Solution heat treatment involves heating the castings to a temperature just below the melting point of the alloy for a specified time, followed by sudden cooling, or quenching. Heating the alloys in this way increases the amount of alloying elements that are in solid solution in the aluminum, thereby effecting a more efficient distribution of the alloying elements. Quenching causes the elements that are in solid solution at solution-treatment temperature to be retained in that condition upon cooling.

If solution heat treatment is followed by artificial aging, some of the alloying elements are precipitated in the alloy, which further increases the strength and hardness. Prolonged artificial aging provides dimensional stability, as already mentioned, but the strength and hardness pass through maximum values and drop, and at the same time the elongation may increase somewhat, in the process.

Machining

As mentioned in the beginning, the ease with which aluminum can be machined is one of the important advantages of aluminum castings as compared with castings of other metals. Although the same general methods used with other metals can also be applied to aluminum, somewhat different procedures are necessary for optimum production.

Relatively high machine speeds are recommended. In fact, for most operations on the majority of alloys the highest speeds of which the machines are capable usually

will give best results. Even higher speeds than those ordinarily possible with standard machines could be used successfully, but larger driving motors probably would be required.

Special attention to cutting tools is necessary for maximum production. High-speed steel tools are recommended for the majority of alloys; but for alloys of high silicon content, which are somewhat abrasive, cemented-carbide-tipped tools give best results. The following recommended practices represent the principal differences between aluminum and other metals with respect to tools:

1. Grind more top and side rake than is common for machining steel.
2. Keep cutting edges sharp and free of burred or wired edges.
3. Maintain smooth, bright tool surfaces free from scratches.

Rake angles may vary somewhat for the various alloys. In general, the larger rake angles are employed for finishing cuts and for alloys that are not free-cutting. As the success of machining aluminum depends to a large extent on tool finish, too much emphasis cannot be placed on the necessity of keeping the cutting edges keen, smooth, and free from grinding wheel scratches, burs, or wire edges. Best results are obtained by finish grinding on a fine or very fine abrasive wheel, then hand stoning with fine or very fine hand stone, or lapping. Whenever possible carbide-tipped tools should be diamond lapped.

With high rates of machining, considerable heat is generated and, therefore, a generous amount of cutting compound is required. When only a coolant is needed either soda water or a soluble oil is used—in such quantities as literally to submerge the work. In some instances compressed air has been employed successfully to cool the work and blow away the chips. If lubrication as well as cooling is required, one of the many ready-mixed cutting compounds is convenient to use. Where heavy cuts and slow feeds are employed for any reason, a high viscosity compound should be used.

Finishing

Perhaps no other commonly used metal offers as broad a range of surface finishes as aluminum. For many purposes, of course, no special surface treatment is needed, as the metal has an attractive appearance which suffers little change under a wide variety of service conditions. Where the plain aluminum surface does not provide the desired qualities, a larger number of easily applied finishes is available, ranging from the purely utilitarian to the highly decorative. They are applied by either mechanical, chemical or electrochemical means, depending on the required surface characteristics and the desired appearance.

Mechanical finishes, such as polishing, buffing, or brushing, produce attractive surfaces which meet all the requirements of many applications. Sandblasting provides an excellent means of cleaning aluminum castings, at the same time imparting a uniform matte surface of pleasing appearance. Sand of various sizes, dust, steelgrit or shot can be used, depending on the desired effect. All these mechanical finishes may serve as either the final surface finishes themselves or as bases for additional finishes. A so-called high-lighted finish is obtained by polishing or buffing the raised parts of a casting and sandblasting the remainder. Such treatments are particularly attractive for spandrels and decorative plaques used for architectural purposes.

Surface effects not possible by mechanical means can be produced chemically, usually at lower cost. Frosted surfaces and Alrok finishes (developed and patented by the Aluminum Co. of America) are commonly applied to small castings. They are resistant to corrosion, but not particularly resistant to abrasion.

Oxide coatings applied to aluminum surfaces by anodic treatment are perhaps the most versatile of all the various finishes available. Like electroplating, the method involves treating the parts in an electrolyte; but unlike electroplating, the parts are connected to the anode of the electric supply circuit instead of the cathode. As a result, aluminum oxide is formed on the surface of the aluminum. This oxide coating is many times thicker than that which forms naturally on exposure to the atmosphere and is also integral with the surface of the metal. These coatings have a hard smooth surface and are resistant to atmospheric corrosion, wear, and chemical attack. They can be impregnated with a variety of dyes or pigments to produce a variety of colors, or with corrosion inhibitors, such as the chromates, to increase the resistance to corrosion.

Unlike other metals, aluminum seldom is electroplated for protection, but is often plated to produce an attractive finish or one having higher resistance to wear. Chromium, nickel, copper, brass, silver, gold, and oxidized modifications of these elements all can be applied to aluminum. The most common plated finish comprises successive deposits of copper, nickel and chromium over a zinc base. Brass, iron, silver or chromium can also be applied over the zinc coating.

Paint, lacquer or enamel sometimes provides the most economical means of obtaining the required decorative or protective effect. When paint is used only for decoration, little surface preparation is required, simple cleaning with a solvent usually being sufficient. When used for protection, however, greater precautions must be observed in preparing the surface, as with other metals. Selection of the proper primer is one of the most important steps, zinc chromate providing excellent corrosion-inhibitive properties. Once the surface has been primed, almost any durable exterior paint, enamel or lacquer can be applied by brushing, spraying, or dipping. Both the chemical and anodic oxide finishes form excellent bases for paint.

Conclusion

Manufacturers having difficulty in obtaining castings of other types in sufficient supply are turning to aluminum for an increasing number and variety of casting applications. They are finding that not only are aluminum castings in plentiful supply, but also that the aluminum foundries, with improved facilities, methods, and alloys developed during World War II, are better equipped than ever before to meet their expanding needs.

Whether in designing an entirely new casting or in substituting aluminum for some less plentiful metal, it is important that the design principles applicable to aluminum be followed if the potentialities of this versatile metal and its alloys are to be realized fully. When these design principles are followed, users often find that aluminum castings, with all their many advantages in an increasing variety of application, frequently can be brought to the point of assembly at lower cost than castings of other metals.

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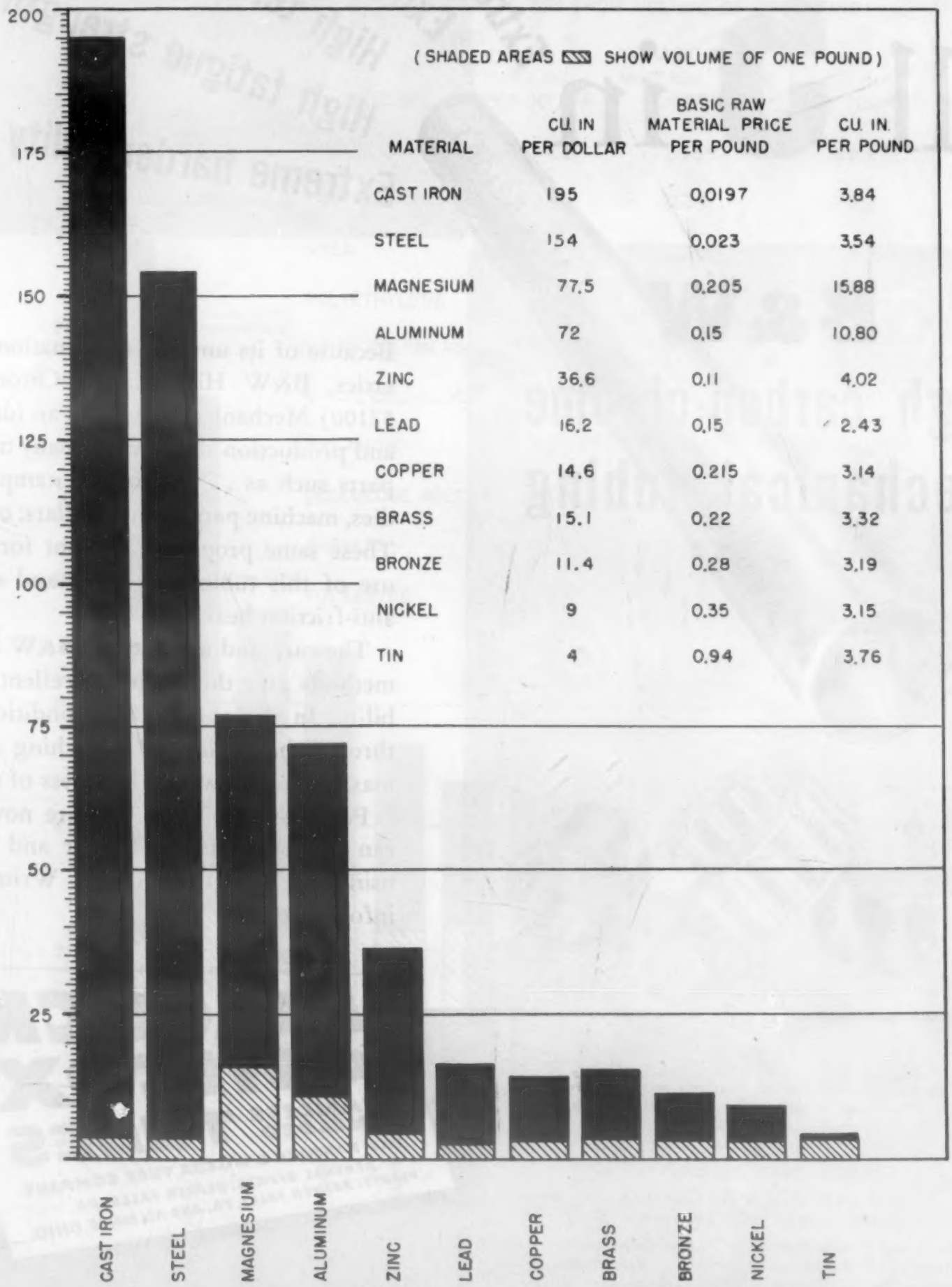
MATERIALS & METHODS **Engineering File Facts**

NUMBER 156
March, 1948

MATERIALS: Metals, General

Price-Volume Ratios of Metals

Quantity Purchasable for One Dollar (Jan. 1948)



MATERIAL	CU. IN PER DOLLAR	BASIC RAW MATERIAL PRICE PER POUND	CU. IN. PER POUND
CAST IRON	195	0.0197	3.84
STEEL	154	0.023	3.54
MAGNESIUM	77.5	0.205	15.88
ALUMINUM	72	0.15	10.80
ZINC	36.6	0.11	4.02
LEAD	16.2	0.15	2.43
COPPER	14.6	0.215	3.14
BRASS	15.1	0.22	3.32
BRONZE	11.4	0.28	3.19
NICKEL	9	0.35	3.15
TIN	4	0.94	3.76

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TA-1416-M

NUMBER 157
March, 1948

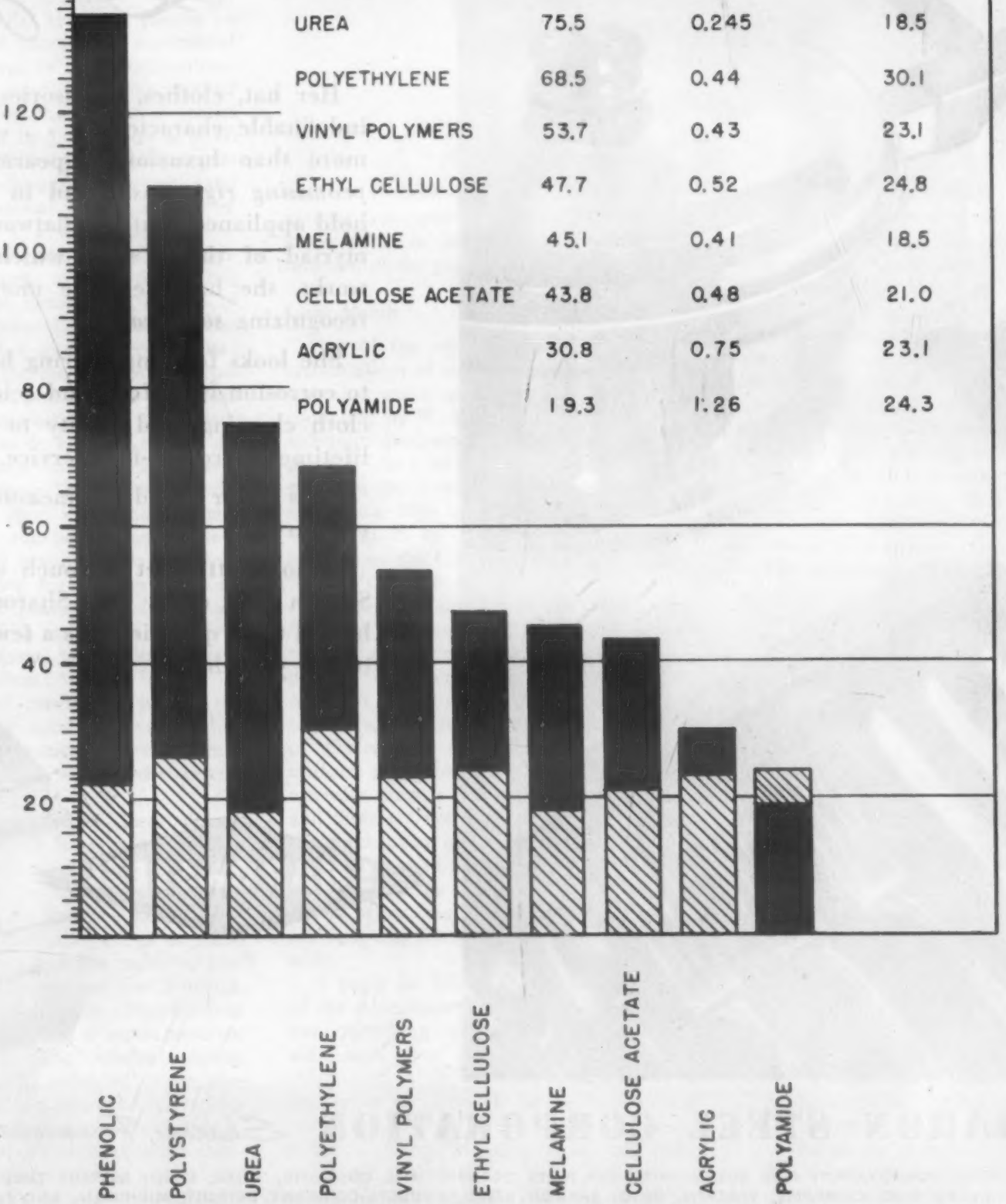
MATERIALS: Plastics, General

Price-Volume Ratios of Plastics

Quantity Purchasable for One Dollar (Jan. 1948)

(SHADED AREAS ▨ SHOW VOLUME OF ONE POUND)

MATERIAL	CU. IN. PER DOLLAR	BASIC RAW MATERIAL PRICE PER POUND	CU. IN. PER POUND
PHENOLIC	134.5	0.165	22.2
POLYSTYRENE	109	0.24	26.2
UREA	75.5	0.245	18.5
POLYETHYLENE	68.5	0.44	30.1
VINYL POLYMERS	53.7	0.43	23.1
ETHYL CELLULOSE	47.7	0.52	24.8
MELAMINE	45.1	0.41	18.5
CELLULOSE ACETATE	43.8	0.48	21.0
ACRYLIC	30.8	0.75	23.1
POLYAMIDE	19.3	1.26	24.3



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MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Progress in Metals Development Work

Condensed from Papers of the American Institute of Mining & Metallurgical Engineers

An important group of technical papers were presented at the technical sessions of the Metals Divisions of the American Institute of Mining & Metallurgical Engineers in Chicago last October. A number of these papers are digested here.

Plating Molybdenum and Tungsten

Although molybdenum and tungsten have high corrosion and temperature resistant properties, they are expensive and their fabrication is difficult. However, plating on base metals would provide an economical means of using them in many applications. So a search for a practical plating method was undertaken and the successful results reported in a paper by J. J. Lander & L. H. Germer of the Bell Telephone Laboratories ("Plating Molybdenum, Tungsten and Chromium by Thermal Decomposition of Their Carbonyls," T. P. No. 2259).

The paper describes the plating of molybdenum and tungsten, and of compounds and alloys of these metals, by pyrolysis of their carbonyl vapors. Chromium has also been plated by this method with limited success. Probably the most important products that have been obtained are the alloys with carbon, and the carbides of the metals. Either molybdenum or tungsten can be deposited upon a base metal as a coherent and adherent coating. The hardness of the coatings depends upon the carbon content of the plating; it can be regulated over a wide range. Those coatings containing considerable carbon are harder than sapphire.

This method of plating has also yielded new carbides, sulfides and oxides of molybdenum and tungsten, and alloys supersaturated with carbon.

In this carbonyl method of plating the base need not have good electrical conductivity, as in electrochemical processes. Thus, low melting glasses, as well as other ceramics, can be plated.

The few products which have already been studied seem to have many possible applications. Pure molybdenum and tungsten coatings can be useful in electronic equipment and in the field of high temperature chemistry. The hard alloys of these metals with carbon, and the carbides, provide good wearing surfaces for bearings, dies, rolls, and other tools. Molybdenum sulfide may be useful as a semi-conductor or as a lubricant. The carbonyl plating process is also readily extended to the production of metallic and nonmetallic particles having a wide range of dimensions.

The process has, of course, certain technical difficulties. The article to be plated must be exposed at the correct elevated temperature to a controlled flow of the proper gaseous atmosphere. Unusual precautions are required in the preparation of the surface and of the plating gas.

Light Metals

One of the ever recurring problems in certain alloys of aluminum is that of stress-corrosion cracking. An investigation was conducted by W. D. Robertson of the Massachusetts Institute of Technology to evaluate the effect of tensile and compressive stress on the corrosion and stress-corrosion of 24S, a high strength aluminum alloy ("The Effect of Tensile and Compressive Stresses on the Corrosion of an Aluminum Alloy," T. P. No. 2281).

Three important conclusions were drawn from the test results: (1) The type of corrosion, general or intergranular, is independent of the existence or nature of the applied stress. It depends only on the metallurgical condition with respect to the development of preferential corrosion paths by non-uniform precipitation. (2) The function of a tensile stress is that of an accelerator only and therefore not a primary component of the mechanism of intergranular corrosion. (3) An applied compressive stress is without effect either on the type or rate of attack when the metallurgical conditions are such that intergranular corrosion is possible.

A paper by W. L. Fink & L. A. Willey of the Aluminum Co. of America discussed the quenching of high strength aircraft aluminum alloy, 75S ("Quenching of 75S Aluminum Alloy," T. P. No. 2225). The properties of 75S alloy in the heat treated tempers, like those of many other aluminum alloys, are affected by the rate of quenching. Sufficiently slow quenching impairs the strengths and resistance to corrosion of the alloy. The range through which tensile properties are most adversely affected by a slow quench is from 750 to 550 F.

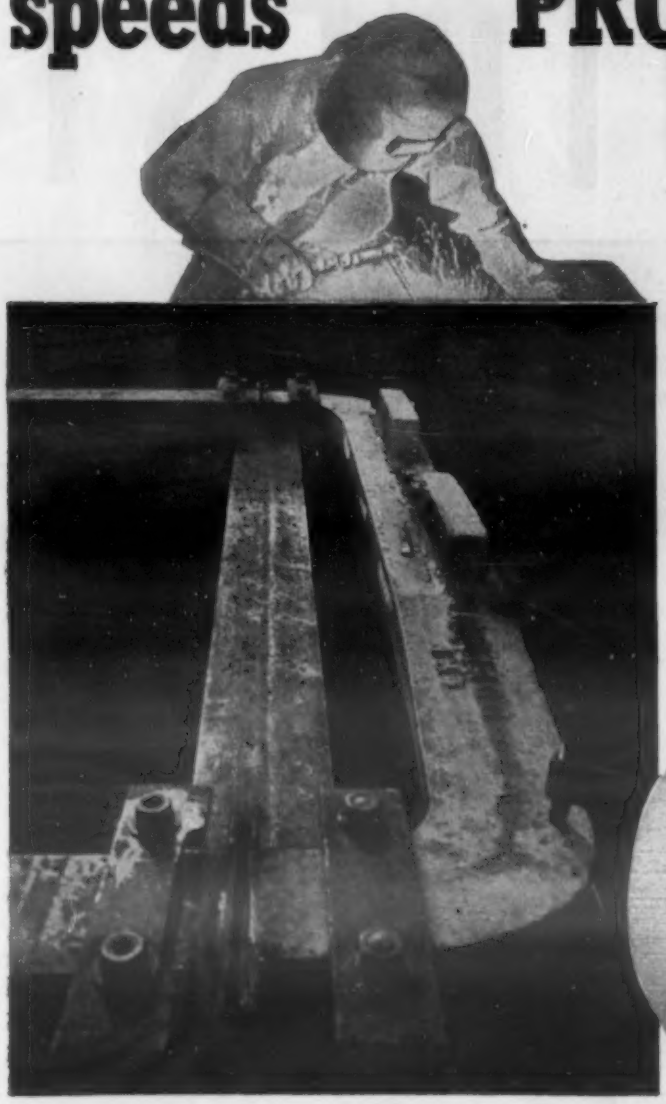
When the average quenching rate through that range exceeds 800 F per sec., maximum strengths and resistance to corrosion are obtained. When the average quenching rate over the critical range lies between 800 F per sec. and 200 F per sec., the strengths are impaired slightly, but resistance to corrosion is substantially unaffected. At rates down to 35 F per sec., strengths decrease more rapidly and resistance to corrosion drops to a minimum. At still lower rates the strengths decrease very rapidly, but the resistance to corrosion improves.

The percentage change in strength for a given quenching rate is the same for heavy extrusions as for sheet. Of course, a given quenching procedure will give a lower rate of quench for the heavy sections—especially at the center.

Research on the solution heat treatment and aging of magnesium alloy AZ92 (formerly ASTM No. 17 and also known as Dowmetal C or AM260) was the subject of another paper in the light metals field ("Factors Involved in Heat Treating a Magnesium Alloy," T. P. No. 2282). Authored by A. E. Flanigan, I. I. Cornet, R. Hultgren, J. T. Lapsley & J. E. Dorn, all of the University of California, the paper records the effects on the properties of AZ92 of various solution heat treatment and aging schedules. Following are a few of the conclusions based on solution treatment of tensile bars:

1. Solution temperatures from 770 to 775 F are most suitable.
2. Local fusion occurs during solution treatment, but has no harmful effect on tensile properties.
3. A coarse grain size increases the time required for homogenization. Foun-

BALDWIN LOCOMOTIVE speeds PRODUCTION with FHP



Cross section of straight gap weld made with FHP in Locomotive mud ring.



● Using the correct M & T electrode . . . plus a wealth of welding "know-how" is the combination that consistently produces high speed, high quality fabrications at low cost in the Eddystone plant of the Baldwin Locomotive Works.

An excellent example is their production line manufacture of water-space frames . . . or mud rings as they are more frequently termed. These frames, used in locomotive boiler assemblies range from 4′ x 5′ up to 10′ x 22′ in size and are made from bars 4″ to 8″ in width and 3″ to 5″ in thickness. All welding is done in straight-sided gaps with 5/16″ Murex Type FHP electrodes at approximately 600 amperes . . . an overloading of current which few electrodes will withstand. Results, however, are extremely high speed operation with no sacrifice whatever in welding quality . . . a neat trick but daily routine at Baldwin where welding ingenuity and M & T electrodes combine to provide welding speed, quality and economy.

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DIGEST

dry control of grain size is therefore important in castings destined for solution treatment.

4. Cracks result from water quenching direct from the solution temperature.
5. Bars quenched from 715 to 750 F after solution treatment are similar in tensile properties to air cooled bars.

Pointing Tungsten Wires

The problem of forming points on wires from 0.002 to 0.010 in. in dia. arose from the introduction of silicon and germanium point contact rectifiers as elements in micro-wave radar. In these devices a pointed tungsten wire makes a delicate contact with a semiconductor. Because the quality of such rectifiers is largely determined by the nature of this contact, considerable attention has been given to the formation of the metal point. An electrolytic method of forming these points was described in a paper by W. S. Pfann of the Bell Telephone Laboratories ("An Electrolytic Method for Pointing Tungsten Wires," T. P. No. 2210).

The process essentially involves partially immersing the wires to be pointed in an electrolyte in a vertical position. Smooth rounded points are then obtained entirely by electrochemical action. The process is independent of the depths to which the wires penetrate the electrolyte because the points are formed at the surface level. A single wire or many of them at once can be pointed. The method is applicable to wires of different diameters within a limited range.

The electropointing method is simple and rapid. It is quite flexible; a difference in wire size or in the point configuration desired, involves little more than a change in the value of the shut-off current. Points of any desired degree of sharpness can be produced on tungsten and molybdenum. Furthermore, by selection of suitable electrolytes, cathodes and voltages, the principles should be applicable to a variety of metals.

Permanent Mold Cast Iron Castings

Condensed from "Foundry Trade Journal"

The introduction of the Eaton-Erb process into Great Britain, and its development and ultimate establishment as a commercially successful competitive process, have fully justified not only the high initial cost but also the arduous and exacting preliminary work required.

This process involves the continuous casting of cast iron into molds mounted at

DIGEST

the periphery of a large horizontal wheel. The molds are iron castings. Before use, a refractory wash is baked on for protection against direct contact with the molten iron. Each cycle provides for cleaning and sooting of the molds. The molds are filled in succession as the wheel revolves. The time between pouring and removing the castings is governed by the cycle of the machine and the setting of the ejection point. Generally, the casting is removed before the pearlite interval is passed. To eliminate possible chills, to obtain maximum machinability, and to minimize internal stresses, the castings are all heated to a temperature within the pearlite interval and slowly cooled after a sufficiently long holding time to graphitize all but the last traces of iron carbide.

Ferrous castings made in the Eaton-Erb machine have shown better soundness, machinability and wear resistance than sand castings. Many castings requiring complete soundness, such as refrigerator valve plates and hydraulic brake and shock absorber cylinders, present considerable difficulties when conventional molds are used. Such castings made by the present process have been very satisfactory as evinced by total customer rejects of 0.2%.

Increases up to 25% in machining speeds have been achieved on these castings as compared with identical operations on similar shapes and positions with castings made in sand molds. With normal lubrication, under sliding friction (valve guides), continuous rotary motion (refrigerator connecting rods), and intermittent sliding contact (gear teeth), the Eaton-Erb material normally outlasts sand castings from the point of view of wear. (C. D. Pollard, H. A. Redshaw & C. A. Payne. *Foundry Trade J.* (British), Vol. 83, Nov. 20, 1947, pp. 237-245; Nov. 27, pp. 259-264.)

Wartime Materials Developments in Germany and Japan

Condensed from
Reports of the Office of Technical Services

The following reports on technical developments in Germany and Japan during the war have been issued recently by the Office of Technical Services, Dept. of Commerce, Washington 25, D. C.

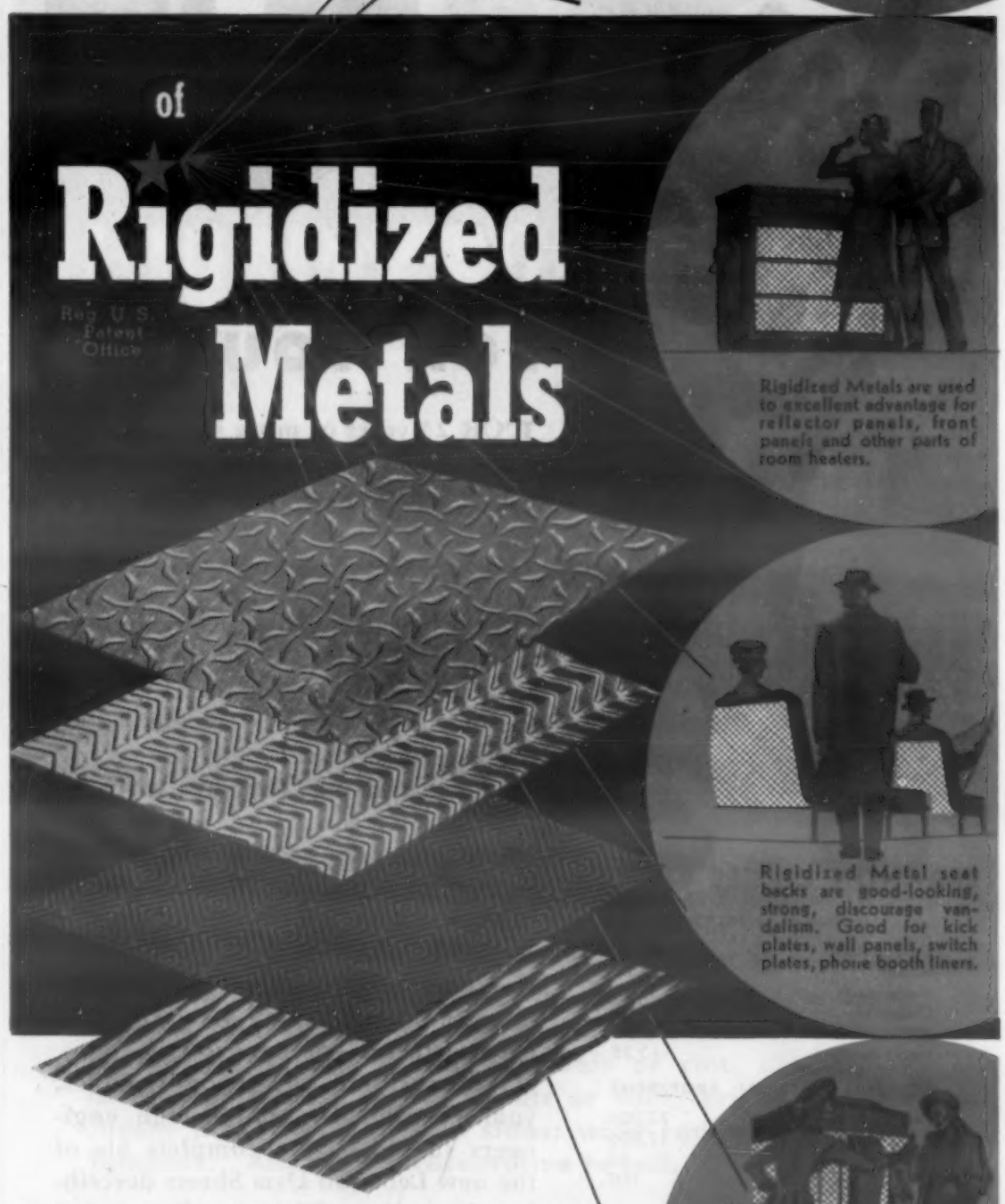
High Temperature Alloys

Technical data on various types of heat resisting alloys considered or used in fabricating turbine blades for gas turbine and jet engines in Germany are given in three reports. One of the reports points out that

your customers will like the look feel service of

Rigidized Metals

Reg U S Patent Office



For parts that must withstand impact and abrasion, use Rigidized Metals. The patterns minimize scratches and finger prints, the extra rigidity keeps the parts flat and true.

Rigidized Metals are used to excellent advantage for reflector panels, front panels and other parts of room heaters.

Rigidized Metal seat backs are good-looking, strong, discourage vandalism. Good for kick plates, wall panels, switch plates, phone booth liners.

Smart, durable Rigidized Metal panels and kick plates enhance the eye-appeal of modern vending machines and juke boxes. Wear well, require minimum maintenance.

Rigidizing is a patented design-strengthening process applied to stainless steel, aluminum and other metals, that adds rigidity and gives the metal a beautiful textured pattern. For widths up to 36 inches, thicknesses to .125—in sheet or strip, coil or cut lengths, solid or perforated metals. Can be colored and highlighted if desired. Readily formed by all customary methods.

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18-8 stainless steels WITH A PLUS FOR YOU . . .

FOR 25 years or more steels with an alloy content of 18% chromium and 8% nickel have shown such remarkable resistance to corrosion that they have earned the name of "Stainless" steels.

Although basically the same, the modern, 1948 models of the "18 and 8" stainless steels have been given a lot of PLUS values by recent metallurgical experience.

The analysis of Lebanon's Circle L 22XM (left) is a typical example. In addition to increases in the percentages of chromium and nickel, approximately 2.25% of molybdenum is added. It enhances the general corrosion resistance to many chemicals and is an important PLUS value to many manufacturers—perhaps to you.

If corrosion is one of your troubles, your metallurgists and design engineers should have a complete file of the new Lebanon Data Sheets describing these alloys. Write for them today.

LEBANON CIRCLE L 22XM

NOMINAL ANALYSIS

Carbon Max.	0.07
Silicon	1.25
Manganese	0.75
Chromium	19.50
Nickel	10.00
Molybdenum	2.25

NOMINAL PHYSICAL PROPERTIES

Tensile Strength	82,000
Yield Point	42,000
Elongation in 2"—%	50
Brinell Hardness	160

LEBANON STEEL FOUNDRY • LEBANON, PA.
"In The Lebanon Valley"

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON ALLOY AND STEEL Castings

CIRCLE L

DIGEST

having experienced production difficulties and service failures with solid turbine blades, the Germans developed a hollow air cooled blade with an air distribution insert which made the use of lower alloy compositions possible. Because of alloy shortages, some thought was given to the use of a ceramic covering for low alloy steels. Surface treatments with aluminum by electroplating and subsequent diffusion had also been considered. (R. Schempp. PB-80356, Use of Heat Resisting Alloys in the Manufacture of Gas Turbine Blades in Germany, 21 pp.)

The second report discusses in detail the composition and use of austenitic, chromium-manganese, and ferritic steels. The development of creep resistant materials was governed by the necessity of conserving nickel, tungsten, molybdenum, chromium, and other alloys. German testing methods, machines, and apparatus are also discussed. (PB-28557, Report on Visit to Germany and Austria to Investigate Alloys for Use at High Temperatures, 89 pp.)

Three methods used by a German company to fabricate gas turbine blades are described in a third report. The methods used were: (1) machine turning a piece of steel bar, (2) deep drawing from a disk of steel, and (3) cold forming and welding.

The steel used was an austenitic chromium-manganese alloy steel. A special lubricant from corn starch, soap, graphite, and waterglass was used in the drawing process. It eliminated the expensive pickling and copper plating procedure prior to each drawing. By using the new lubricant the metal was coated prior to the drawing operation and the coating dissolved with hot water after drawing and prior to annealing. (J. Robinson. PB-81642, German Practice in Fabrication of Gas Turbine Blades, 16 pp.)

Powder Metallurgy

Cost-reducing powder metallurgy techniques developed in Germany are described in several technical reports. The principal report indicates that in developing powder metallurgy techniques the Germans worked along different lines from American metallurgists, especially in the manufacture of sintered carbide hard metals. They relied entirely on the hot press method, while the American industry pressed cold and sintered as a separate step. The Germans surmounted the difficulties usually associated with the simultaneous application of great heat and pressure (that of loss of the molten binder by extrusion) by using carefully weighted pre-pressed charges with a constant apparent density to control the final volume.

The German hot press is of the graphite resistance type, the spring clamped mold being the resister with a separate mechani-

cal or hydraulic system available for applying the top and bottom plunger pressure.

A rotating disk method was universally used for disintegrating all kinds of molten metals, alloys or even emulsions of non-alloying metals. Copper, silver and aluminum powders as well as a number of different powders for research were produced by the rotating disk method.

Production of metal powders by pressure atomization with steam was also used. The shape of the iron powder particles produced by this method is more nearly spherical than those produced in the rotating disk method, but the "pressability" of the particle is found to be less satisfactory. (G. Comstock. PB 39354r, German Powder Metallurgy, 128 pp.)

Another report describes the German methods for manufacturing iron powder cores. It concludes that the carbonyl iron powders used in Germany are of better quality than American powders of the same type. In addition, mixing and insulating material is different although the same components are used. The mixing is of longer duration and is done in a liquid medium. The general method used is pre-insulation followed by drying the powder, then the main insulation, drying, pressing, and aging. Special attention is also being paid to the low carbon (0.1%) and low nitrogen (0.01 to 0.02%) contents specified for some of the German powders. Seven German carbonyl iron powders are listed with their grain size, production method, chemical analysis, electromagnetic constants, and fields of application. (H. L. Krebs. PB-78996, German Methods for the Manufacture of Iron Powder Cores, 15 pp.)

Tungsten-Free Hard Metal

Promising developments in tungsten-free cast hard metal for tooling purposes took place in Germany during the war. In the first tests to develop tungsten-free hard metal, vanadium and titanium were used with iron as a binder. The results were so good that no other metals were tested.

Titanium and vanadium carbide were made by carburizing the oxide or the sesquioxide in a hydrogen atmosphere. The product obtained was ball milled, sifted through a 1000-mesh sieve, then ball milled with iron powder and sieved. The powder was then compressed and sintered.

Early samples produced surprising results. None of the samples possessed sufficient strength to stand up to cuts of more than 1.2 sq. mm. cross section but a few individual samples withstood cutting speeds above those of tungsten carbide hard metals without cratering, according to the report.

At the end of the war the tungsten free hard metal was still variable in quality, but sufficient work had been done to prove

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The first radiant-tube continuous furnace was built by Holcroft in 1936, and is still producing efficiently. The furnace at right shows the simplicity of the Holcroft radiant-tube installation.



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Introduced by Holcroft in 1936, radiant-tube heating of continuous furnaces solved the problem of constructing larger, more durable furnaces for controlled-atmosphere heat treating. This development made possible the high-production furnaces of today.

As applied by Holcroft, this heating method offers the following advantages:

- *Gas, oil or electric firing* may be used, whichever is most economical.
- *Combination oil-gas burners* are available, with quick changeover provided.
- Holcroft burners are of *closed-head design.* Air and fuel are metered, and are progressively mixed as they pass through the tubes. This assures both maximum combustion efficiency and the uniform heating required for maximum tube life.
- The burner design permits *floating control,* with the same superior performance at all rates of heat input.
- All tubes are readily replaced without cooling the furnace; and electric heating elements are replaced without removing the tubes.

These are but typical of the many advantages provided by Holcroft engineering leadership. Each Holcroft furnace is *designed individually* for its specific application, and *complete metallurgical and engineering service* are provided. Thus Holcroft assures *maximum over-all economy* in production heat treat furnaces for EVERY purpose.

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that a very promising tungsten-free hard metal had been produced and that it would equal the performance of the more orthodox hard metals for machining steel, nonferrous metals, and plastics. (PB 78259, Cast Tungsten Carbide and the Production of Tungsten-Free Hard Metal, 73 pp.)

Continuous Casting of Nonferrous Alloys

Several novel machines for continuous casting of light metals and nonferrous alloys were used during the war by the Germans. Two methods of continuous casting were used. One of these, the Junghans method, employs a bottomless ingot mold 12 in. deep of which the upper 2 in. is surrounded by a water jacket for cooling. The rate of downward travel of the ingot is controlled by rolls which engage the solid ingot as it emerges from the mold. The Junghans process eliminates the use of costly iron molds used under the old system. Considerable savings are made in the number of analyses required because the metal cast by the machine is of more uniform quality. Since the extrusion press can always be worked at maximum capacity when using Junghans billets, there is an additional saving in the extruded rod department.

The other method, known as the Zunkel process, is based on the new and original idea of using a mold only slightly higher than the solidifying zone of a downward moving metal strip. The liquid metal is poured directly from the furnace through a short spout slowly and continuously into a water-cooled mold. The metal strip rests on the ram of a hydraulic pump and with the help of the pump the cast strip is lowered into the water. The strip solidifies on the outside only, the core remaining temporarily liquid. Quenching in water chills the metal at once, providing a very fine grain structure.

The quenching process was modified by one German plant which substituted a water spray to strike the metal ingot as it left the mold. The spray form of chilling is of particular importance for aluminum alloys which require a milder cooling of the surface. (F. L. Wolf & I. Egeberg. PB 81641, Metallurgical Practices in Germany, 44 pp.)

Developments in Aluminum

Welding of aluminum containers, employment of a new aluminum alloy known as "K. S. Seewasser," and the use of oxyhydrogen rather than oxyacetylene welding are described in a British report on German aluminum practice.

The new aluminum alloy was used in the production of mine shells and contained 2 magnesium and 1½% manganese. A rather specialized technique of working with it is described in the report. The alloy is used

DIGEST

in the soft condition, in which state it has a tensile strength of 30,000 psi. Generally speaking, the welding was good, although where it was carried out from one side only the penetration was very erratic.

In welding aluminum containers attempts to use a 7% magnesium alloy were unsuccessful because of the so-called "Mausi" effect, the name given to the blistering which occurs adjacent to the welds with consequent reduction in strength. The Germans realized that this blistering was associated with a high parent metal gas content and that the effect becomes more severe with increasing magnesium content. One light alloy manufacturer in cooperation with designers produced a more weldable alloy known as Hy75 or Hy7S. It contained 5.6% magnesium and was stated to have a tensile strength of 40,000 to 48,000 psi.

Gas welding was normally used for all the important joints of aluminum containers used for the transport of milk, gasoline, nitric acid and hydrogen peroxide. Three of six fabricating firms used oxyhydrogen welding in preference to oxyacetylene because it was considered that the former process gives sounder welds and because the flame is easier to manipulate and, therefore, was more suitable for inexperienced wartime welders.

Only one firm used arc welding extensively for main joints, other firms used it only for lightly stressed welds and those not required to be pressure tight. Atomic hydrogen welding appeared to have been used to a very small extent and then only for repair work or for welding very thin materials. (PB 34016, Welding of Aluminum and Aluminum Alloys with Particular Reference to the Manufacture of Pressure Vessels, 33 pp.)

Magnetic Materials

Four magnetic materials not made in the United States are described in a report that surveys the development of magnetic materials in Japan during the war. The four materials are: an iron-aluminum alloy, "Alfer," developed as a substitute for nickel; "Sendust," a high permeability alloy of iron, silicon and aluminum; and two permanent magnet materials, "NKS" and "OP", developed before the war. About 16 other magnetic materials are made in Japan, including a few of the high-nickel, high permeability alloys used in quantity in the United States.

One important new application of magnetic materials in Japan has been the use of Alfer in magnetostriction projectors and microphones. It was also used to replace nickel in the cores of underground vibrators and receivers. (PB 76031, Magnetic Developments in Japan During World War II, 62 pp.)



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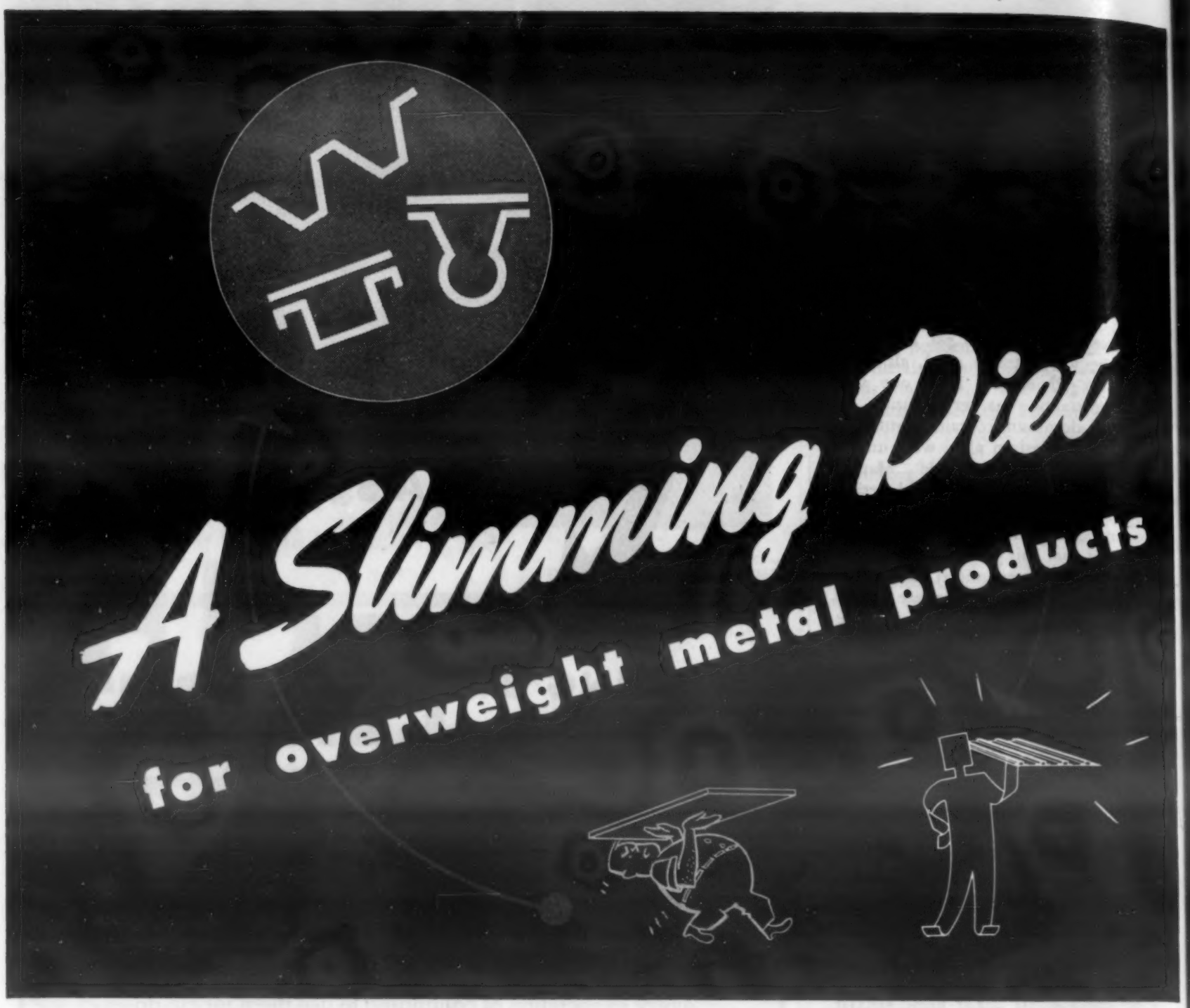
That's versatility: LEA Methods and LEA Compounds doing several jobs (including cut-down and coloring) on a variety of articles (plated, stamped, sand-cast and eventually, die-cast). This wide range of applications may give you some conception of how LEA will fit into your production line. If you are burring, polishing or buffing metals, plastics or woods, LEA, with more than twenty years' experience in the finishing field, may be able to assist you in cutting costs and improving the quality of your finishing.

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Sufficient rigidity can often be obtained with light sheets of ARMCO Stainless Steels by increasing section-depth, such as by corrugating. Where localized deflection is apt to occur, stiffeners like those shown here are often used to strengthen parts subjected to heavy stresses.

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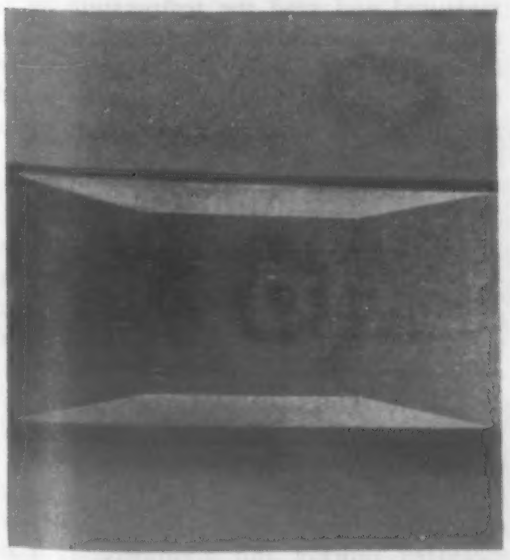
New MATERIALS AND EQUIPMENT

New Metallizing Product Bonds With Smooth Surfaces

A new metallizing product, Sprabond, originated by the *Metallizing Engineering Co., Inc.,* Long Island City 1, N. Y., tends to revolutionize the conventional metallizing process.

Where it had previously been necessary to perform such operations as undercutting, roughening, grooving and cutting dovetails in preparing the surface for metallizing, the new product reduces the conventional 8-step procedure to three steps. Formerly, bonding was mechanical in nature.

Sprabond, it is claimed, produces a bond of a physichemical nature. As a result it is not necessary to perform any surface preparation other than rough turning or grinding to produce a perfectly clean contact area. The new product is then applied to the cleaned surface by means of a metallizing gun through which the Sprabond wire is fed. The spraying temperature is about 6300 F and the metal is fed through the gun at a rate of speed dependent upon the wire melting point and size of wire used.



The worn shaft above was rough turned and built up with Sprabond.

The use of Sprabond is highly satisfactory on all common steels, stainless steels, Monel, nickel and chromium-nickel alloys, cast iron, cast steel, magnesium and aluminum. It provides a fair bond with lead, tin, zinc and galvanized iron but does not bond well with copper, brass, bronze, chromium plate or Duriron.

Developmental work is in progress to improve its bonding on intricately shaped parts and in the corrosion resistant field.

Flexible Welder for Submerged Melt Welding

A new flexible welder for submerged melt welding has been developed by *Linde Air Products Co.,* 30 E. 42 St., New York 17.

The machine is particularly useful for making welds that are inaccessible for fully automatic welding, making short welds where it is not worth while to mechanize the operation, building up deposits of almost any size or shape, and depositing metal to repair weld or casting defects. The welder can be used as a primary welding tool in a small welding shop or as a supplementary tool for fully mechanized installations.

The welding nozzle on this machine is at the end of a 20-ft. long flexible hose. It can be moved from one weld to another without stopping to set up tract, carriage, or other guiding equipment. The flexible hose, connecting the nozzle to the main machine assembly, contains the welding current cable, and two tubes through which the welding rod and the granular material are fed. Bare welding of any size up to 5/32-in. dia. in the standard 25-lb. coils can be used in the machine.

Granular welding composition is continuously supplied to the welding nozzle by compressed air from a storage tank included on the main machine assembly. This tank, holding about 75 lb. of the material, provides an adequate supply so that an entire 25-lb. coil of welding rod can be fed without interruption and without danger of flash, which might occur frequently if a smaller supply were used. The granular material flows by gravity from the welding nozzle and the operator controls the depth of the layer laid down by the height at which he holds the nozzle above the work surface.

The welder has a capacity of 900 amp., either direct or alternating current, which can be supplied from any welding generator or transformer. Compressed air at about 35 psi. pressure is required to force the granulated composition through the flexible tube to the nozzle. Only a small amount of compressed air is used, about 110 cu. ft. being required for each tank full of welding composition for each 25 lb. of rod deposited.

New Hydraulic Press Straightens Large Parts

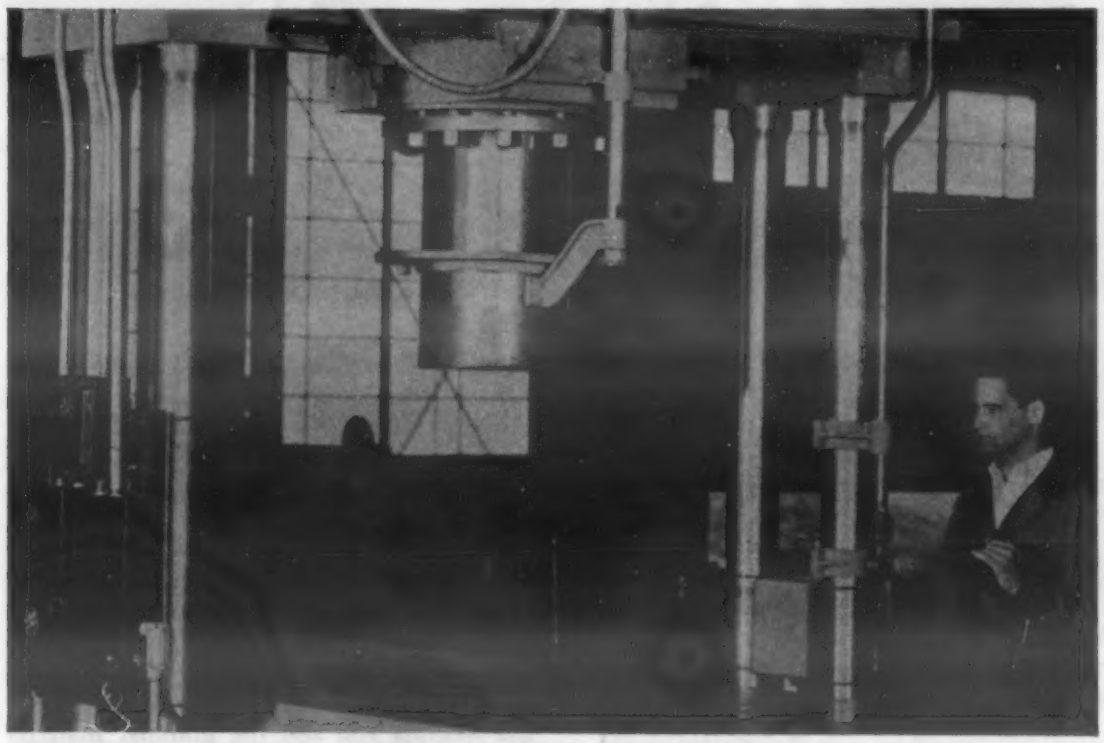
A 200-ton hydraulic press for straightening weldments, castings and other large area parts has been designed by the *Hydraulic Press Mfg. Co.*, Mt. Gilead, Ohio. A unique feature of this press is that maximum pressure can be applied at any point within a 120-in. by 38-in. area of the stationary press bed. Pressure ram is movable for 120 in. in a horizontal plane along the bed and can also be traversed for 38 in. in a horizontal plane at right angles, between the two sets of strain rods.

Positioning of the ram is controlled electrically by the operator at a central control station. Vertical hydraulic traverse of the ram to and from the work is controlled by convenient hand lever at the control station. A dial type hydraulic pressure gage informs the operator the exact pressure being applied to the work.

The H-P-M Co. has designed and built a large number of straightening presses which provide for the pressure unit to be traversed along the bed, but this press represents the first known application of a pressure unit which not only can be traversed along the bed, but can also be traversed at right angles to the bed.

This 200-ton straightening press is a completely self-contained unit requiring only electric power for operation. An H-P-M Hydro-Power radial variable delivery type pump generates the hydraulic pressure for operation. Oil is used as the pressure medium.

Maximum daylight space between ram facing and bed is 36 in. Maximum ram travel is 18 in. The hydraulic pump is driven through flexible coupling by a 5-hp. electric motor. All hydraulic equipment (pumps, valves and controls) as well as the press flame members were designed and manufactured by the Hydraulic Press Mfg. Company.



The pressure ram of this 200-ton hydraulic press is capable of being traversed at right angles to the bed as well as along the bed. Maximum pressure can be applied at any point within the press bed.

Strippable Coatings Protect Materials

Two new strippable coatings have been introduced to protect metal surfaces during shipment, storage, handling and some types of fabrication.

Copeel, an easily removable plastic material, was developed by *Maas & Waldstein Co.*, 438 Riverside Ave., Newark. This product provides an envelope type coating which protects metals and finished products from corrosion and scratches. Copeel is also water resistant and finds wide application in the protection of machined precision parts. It can be removed easily by simple hand stripping.

Peelcote, a vinyl based coating with complete chemical inertness, was designed by the *Watson-Standard Co.*, 225 Galveston Ave., Pittsburgh, to protect metals against defacing and corrosion. It can be applied by spray or dip methods, dries rapidly, and can be removed quickly and cleanly by peeling.

Liquid Inhibitor Effective In Cold and Hot Pickling

Enthone Inhibitor No. 9 is being produced by *Enthone, Inc.*, 442 Elm St., New Haven, Conn.

This product is a liquid inhibitor that dissolves readily in acid solutions. It is especially important where exhaust ventilation is not available. Another feature is its inhibiting action, in both hydrochloric and sulfuric acid solutions, which is over 90% and in some cases ranges up to 98%.

Enthone Inhibitor No. 9 is suitable for use in both cold and hot pickles. Since it does not attack the base metal and leaves a bright surface, it provides an excellent base for plating or hot coating.

● *Industrial Products Co.*, 2820 N. Fourth St., Philadelphia 22, has announced a new vacuum lifter designed for lifting, feeding and positioning sheets of metal and other materials in stamping machines and die-presses. It operates by striking rubber cup against material to be handled. This produces and retains a vacuum within the cup until it is released by depressing conveniently located trigger. Overall length of the lifter is 15 in.; height at cup end 1½ in.; weight 4½ oz.

Radiation Pyrometer Measures Temperatures Above 1000 F

A new radiation pyrometer has been designed by the *Pyrometer Instrument Co.*, 103 Lafayette St., New York, to determine temperatures above 1000 F by thermo-electric principles. This new instrument is self-contained, weighs less than 2 lb., is direct reading, and requires no outside connections, lead wires, batteries or other accessories.

The pyrometer is automatic in its operation and requires no skill or previous instruction in its use. It is only necessary to sight the instrument at the object being measured and read the temperature on its direct reading scale. The special indicator locking device holds the pointer at the reading obtained until a button is pushed permitting the indicator to return to its zero position.

The operation of the instrument is based upon the established laws of radiant heat. A very sensitive vacuum thermocouple within the instrument is sighted at the object being measured and the resultant electro-motive force operates a galvanometer calibrated in direct degrees of temperature. The instrument is constructed in a steel housing so that it is immune to external magnetic and electrical influences.

The pyrometer is applicable wherever spot temperatures above 1000 F are to be measured quickly and accurately, such as in all types of furnaces, forgings, fire boxes, kilns, retorts, etc.

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We welcome inquiries on any phase of your need for castings whether of ABK Metal (wear resist), Gray Iron or Meehanite® as made by Brake Shoe.

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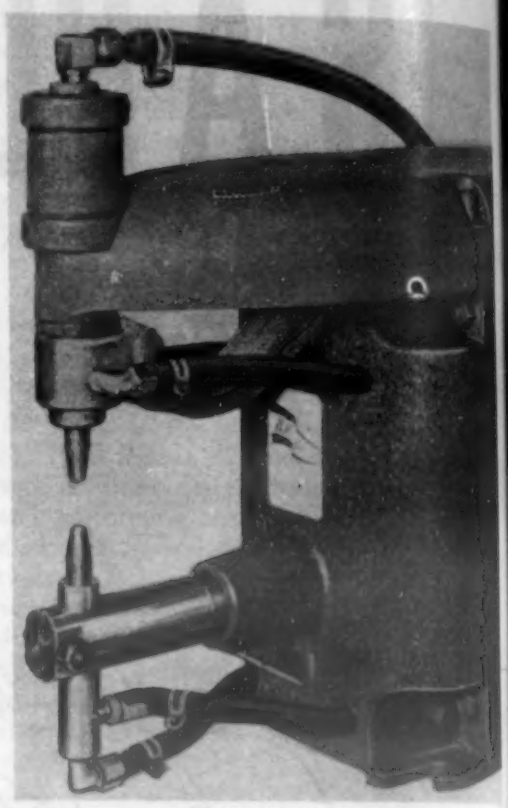
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BRAKE SHOE AND CASTINGS DIVISION

230 PARK AVENUE, NEW YORK 17, N. Y.

Air Spot Welder Combines Economy, Versatility

The new 3-Kva spot welder made by *Banner Products Co.*, 4951 N. 29 St., Milwaukee 9, Wis., answers the need for a low cost, versatile, air-operated spot welder. Its outstanding features include ease of operation in any position, rapid adjustment to new applications, and a minimum of maintenance because of its basic simplicity in design.



This compact spot welder can be adjusted quickly and operated easily in any position.

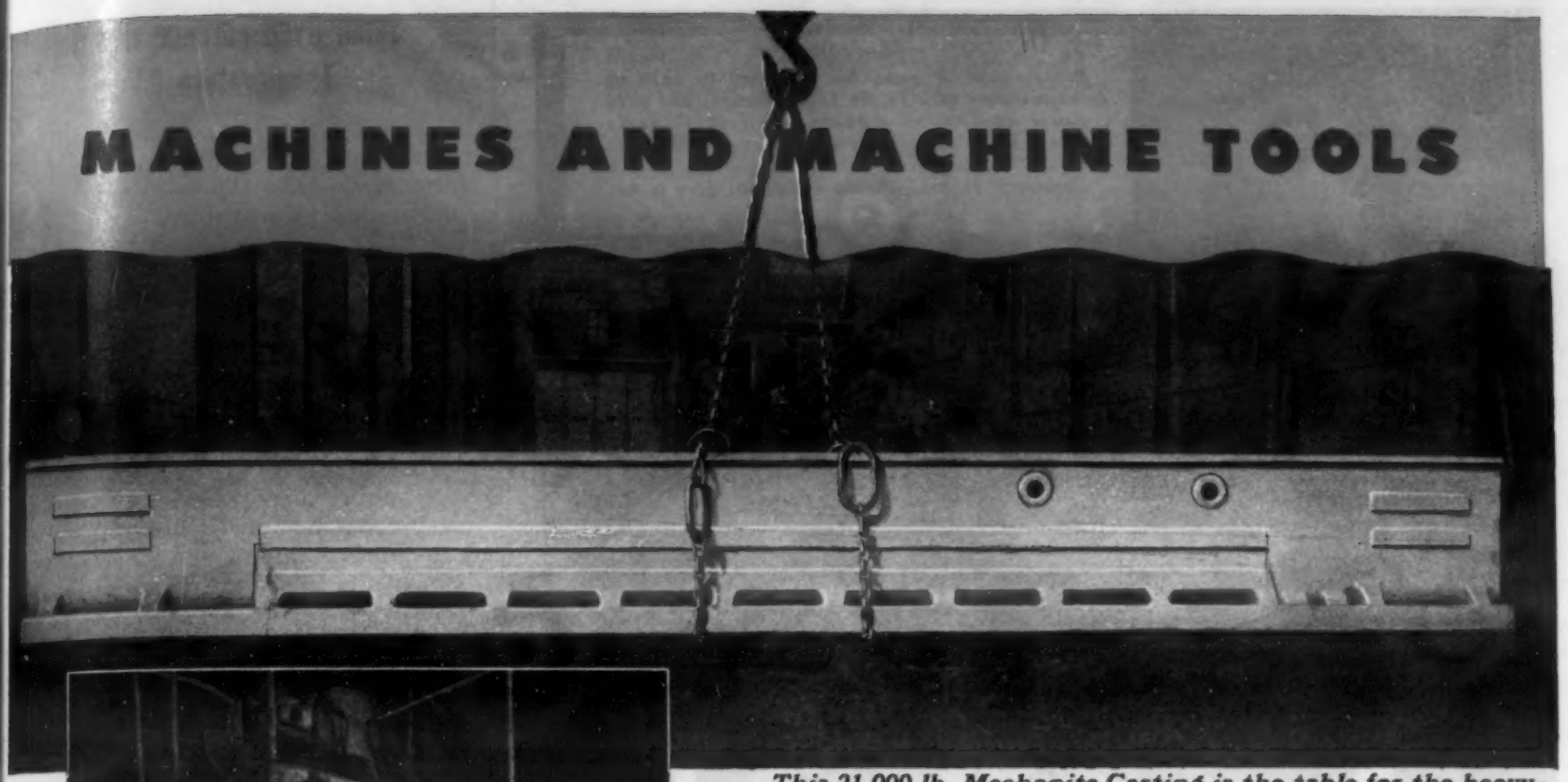
A pilot operating foot switch initiates a ¼-in. 3-way selenoid air valve which, together with the air regulator, lubricator, strainer and gage, is compactly installed in a fabricated stand. Because of their compactness, several of these units can be set up in a series and operated simultaneously by a single timer and foot switch on parts requiring several welds.

Refractory Metal Powder Has Good Green Strength

Exceptional green strength has been obtained in a new type 18:8 stainless steel refractory metal powder by *Charles Hardy, Inc.*, 420 Lexington Ave., New York 17.

The green strength of stainless steel compacts is ordinarily comparable to that of other refractory powders. However, a green strength which compares favorably with that of iron and brass compacts is obtained if the Hardy type 18:8 stainless steel uncompacted powder is heated at 900 F for 30 min. in a neutral or reducing atmosphere.

Surgical appliances, laboratory apparatus, decorative metalwork and blower parts are a few of the many uses to which the Hardy product can be applied when green strength and corrosion resistance are required.



This 21,000 lb. Meehanite Casting is the table for the heavy-duty Billeteer, a quality component of a precision machine.



Bonnot Company Billeteer in action.

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WITH MEEHANITE® CASTINGS

A Billeteer, like all machine tools, must be "built for action." So described by its builder, The Bonnot Company, Canton, Ohio, the Billeteer illustrated is a precision machine in every respect and is well known in the steel industry for its accomplishments in chipping steel billets.

The 21,000 lb. Billeteer table shown is a MEEHANITE casting in keeping with the high quality standards of the builder. As a MEEHANITE casting the table is assured of providing the necessary high strength, better vibration absorption, dimensional stability and density required of such precision machinery castings.

In the machine tool industry many leading manufacturers are familiar with and make extensive use of the *better* properties provided by MEEHANITE castings.

For further information write for our booklet on MEEHANITE machine tool castings.

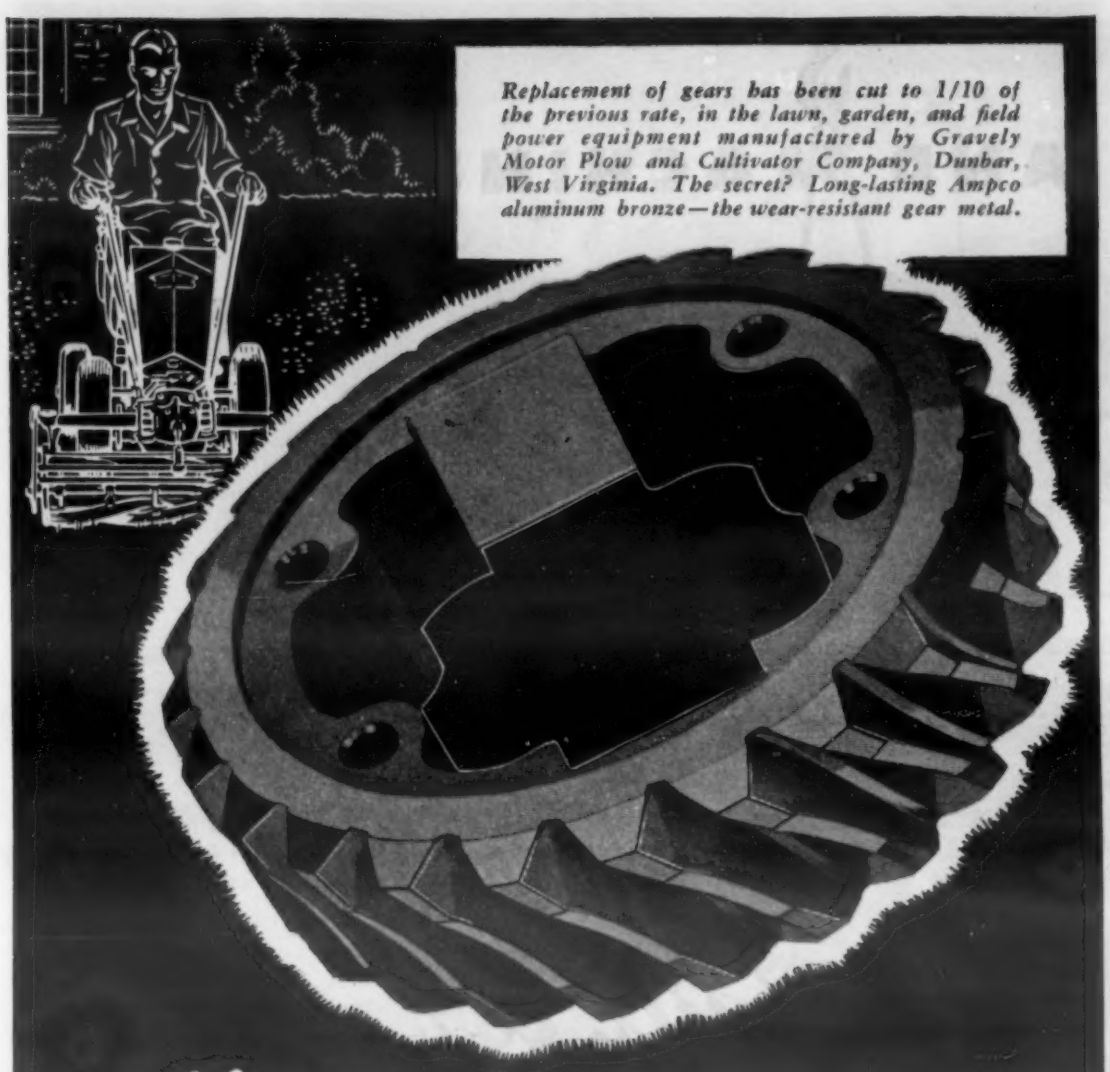
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H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
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Johnstone Foundries, Inc.	Grove City, Pennsylvania
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Kochring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
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E. Long Ltd.	Orillia, Ontario
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario

"This advertisement sponsored by foundries listed above."



Wear-resistant aluminum-bronze castings reduce gear replacement rate from 20% to 2%

Mowers, tractors, and other garden power equipment lead a rough life — and they have to be built to take it! Critical differential worm gears suffer particular wear, ordinarily have a high replacement rate. But wear-resistant Ampco aluminum bronze solved this problem for Gravely Motor Plow and Cultivator Company, who are justly proud of their reputation for quality products. Replacements fell to a fraction of the former rate.

Hundreds of companies use durable Ampco bronze parts in their products as selling features . . . look for them as a mark of quality when they buy . . . replace ordinary bronze parts in their present equipment with Ampco bronzes, to reduce maintenance frequency and replacement costs.

Order Ampco Metal and Ampcoloys in centrifugal- and sand-castings, extrusions or forgings, according to your requirements. Let your nearby Ampco engineer help you select the proper grade for your needs. For complete information about Ampco Metal and Ampcoloys, write for bulletins.

AD-35A

Ampco Metal has 7 outstanding performance advantages

Excellent bearing qualities • High strength-weight ratio • High compressive strength • High impact and fatigue values • Corrosion resistance • Wear resistance • Efficiency at extreme temperatures.

Ampco Metal, Inc.
Dept. MA-3 • Milwaukee 4, Wis.
Field Offices in Principal Cities

AMPCO
TRADE MARK
REG. U. S. PAT. OFF.

Small Oven Furnace Has Wide Temperature Range

An entirely new and advanced small semi-muffled gas fired oven furnace with a temperature range of 300 to 2400 F (and any intermediate temperature) has been designed by *Sunbeam-Stewart Industrial Furnace Div.* of *Sunbeam Corp.* New type burners permit a 95% turndown range of fuel. The uniformity at low temperatures is obtained by increasing air over gas ratio, thus heating by convection.

The temperature range of 300 to 2400 F enables this new oven furnace to be used for a wide variety of work such as annealing, carburizing, hardening, preheating, tempering, and general heat treating. The extreme flexibility of this Sunbeam-Stewart semi-muffle oven furnace makes it ideal for general toolroom use.

The staggered position of the nozzle mixing range burners results in a circular turbulence throughout the heating chamber.

The outer shell is entirely constructed of steel and cast iron to eliminate the possibility of warpage at high temperatures. A patented "Seal-tite" door maintains a constant seal between door and furnace proper. The furnace is adaptable to various types of standard temperature control which are readily available.

● Quick and more accurate carbon checks can be obtained through the use of Carbon Determinator No. 3003, manufactured by the *Harry W. Dietert Co.*, 9330 Roselawn Ave., Detroit 4, Mich. Consistently reproducible results are claimed obtainable on all metals and organic or inorganic materials within 2 min. after the sample has been weighed.

New Mold Steel Offers Added Ductility, Hobability

A vanadium treated, cold melt, electric furnace mold steel designed especially for cold hobbed cavities has been provided by the *Carpenter Steel Co.*, 335 W. Bern St., Reading, Pa.

Called Mirromold, the new mold steel has been developed to give the plastic mold industry three basic advantages: (1) maximum hobability, (2) uniform response to heat treatment, and (3) inherent cleanness.

Mirromold offers the ductility and ease of hobbing normally found only in hobbing irons. It is carefully annealed to show a Brinell hardness of not more than 90 (Rockwell B 55). This represents about the lowest hardness obtainable in any steel. The addition of vanadium serves as a refining agent and insures a tough, durable case in the heat treated mold. To insure cleanness in every bar, Mirromold under-

(Continued on page 128)



MEETING OF MINDS

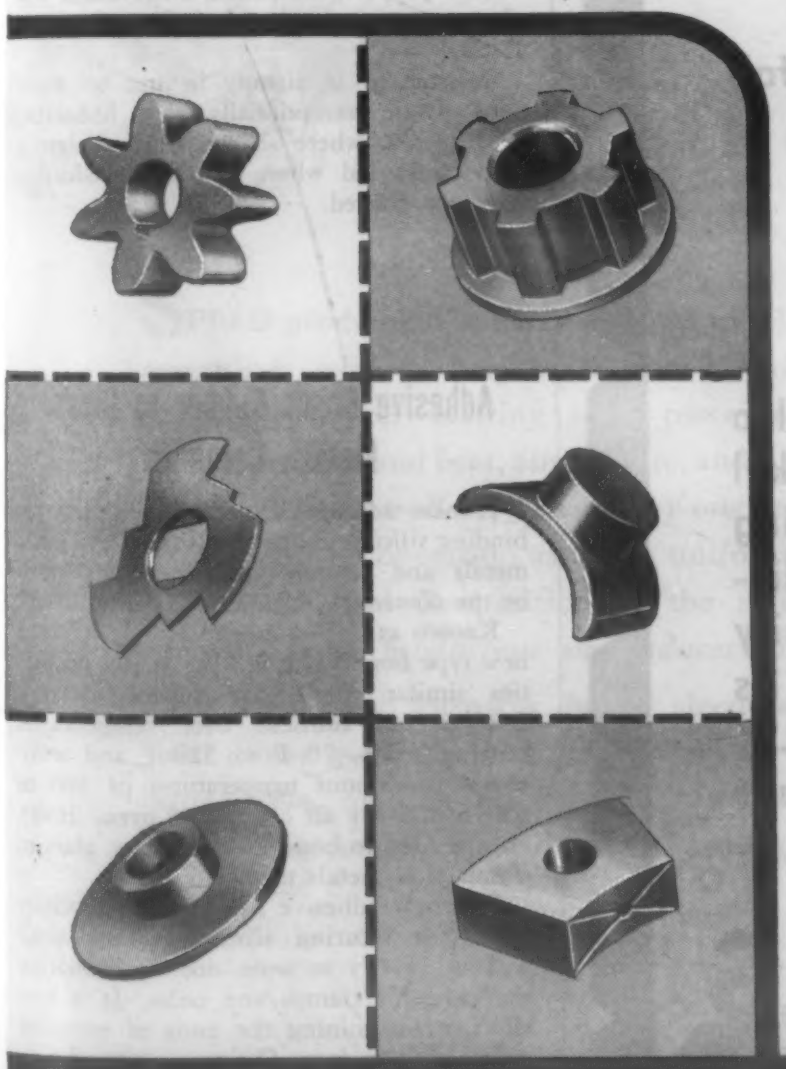
ON THE APPLICATION OF POWDER METALLURGY

Before production starts on a metal powder part by Moraine, there must be a meeting of minds—yours and ours.

You **must be convinced that powder metallurgy offers you specific advantages in reduced costs, a better finished product or both.**

We **must be convinced that powder metallurgy is the logical process to use, providing benefits not otherwise obtainable.**

To reach this agreement, Moraine Products applies the broad practical experience gained as a leading manufacturer of automotive parts and products, as well as a producer of metal powder parts for industry. The result is a realistic approach to your parts problem that lets our minds meet . . . with our feet on the ground!



General Requirements for Metal Powder Parts

1. Shape permits good die fill and even density. 2. Volume justifies initial tooling costs. 3. Physical properties are within range attainable.

MORAINE PRODUCTS

DIVISION OF

GENERAL MOTORS

DAYTON, OHIO

METAL POWDER PARTS . . . BY MORAINE

"FALLS BRAND" ALLOYS
AMERICA'S LARGEST PRODUCERS OF ALLOYS

FALLS MANGANESE COPPER

Manganese copper is used principally for the introduction of Manganese into brass, bronze and nickel silver. It is supplied in the form of shot or bars that can be cut to any reasonable weight that the user may require.

GRADE "A"—will conform to the following composition:

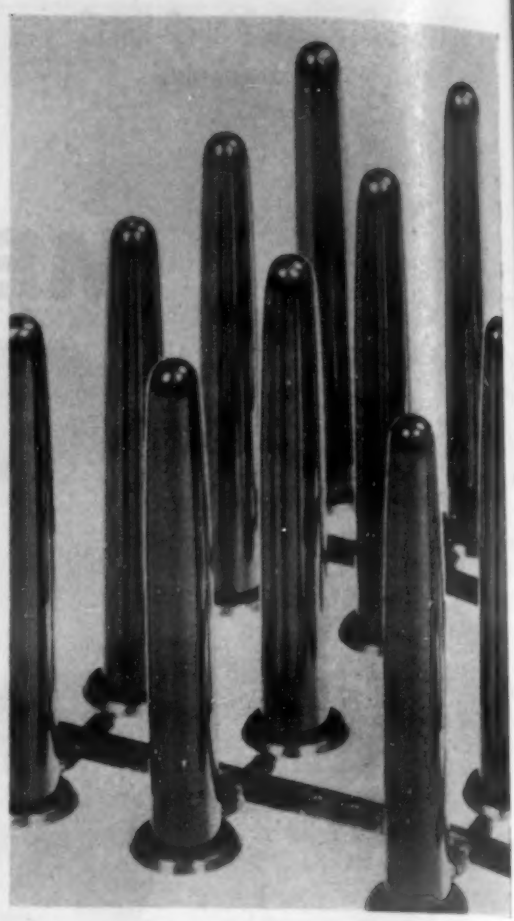
Manganese	28.5 to 31.5%
Total Impurities	0.5% Maximum
Copper	Balance

GRADE "B"—will conform to the following composition:

Manganese	25.0 to 30.0%
Total Impurities (Principally Iron)	3.0 to 5.0%
Copper	Balance

FALLS MANGANESE COPPER is also used for deoxidizing brass, white nickel casting alloys and nickel silver containing lead. As well as being an active deoxidizing agent Manganese has great affinity for sulphur and this combined with its ability to absorb gasses makes "FALLS" MANGANESE COPPER a very important alloy for use in the foundry.

NIAGARA FALLS
Smelting & Refining Division
Continental-United Industries Co., Inc.
BUFFALO 17, NEW YORK



These multiple-hobbed cavities for fountain pen bodies are made from Mirromold.

goes a hot acid etch test before passing inspection.

After heat treatment, the yield strength of the core is approximately 38,000 psi. When properly hardened, Mirromold will show a surface hardness of about Rockwell C 62.

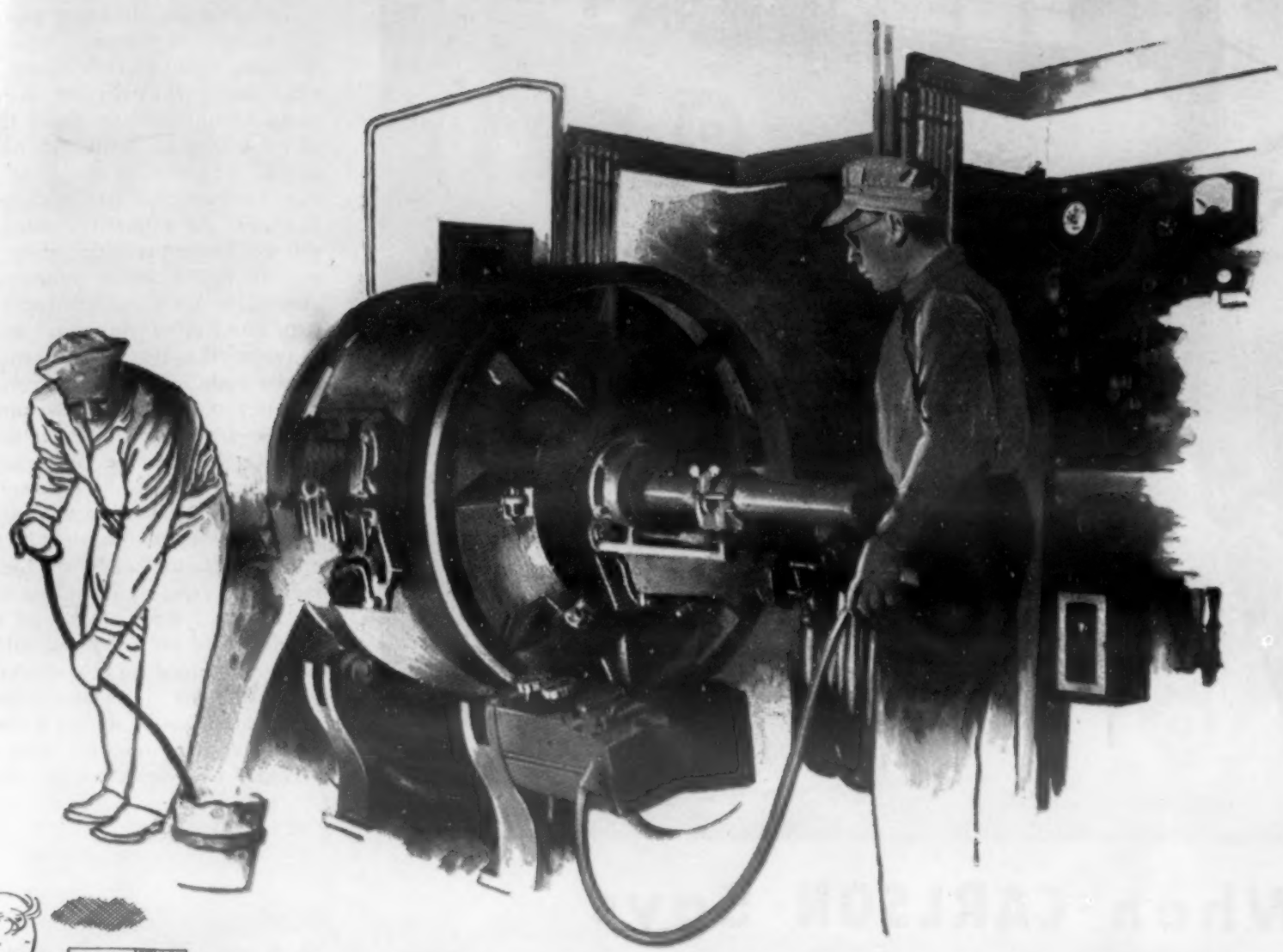
Mirromold is already in use on many jobs where exceptionally easy hobability is required, where sharpness of design is important, and where medium production runs are desired.

Adhesive Bonds Rubber to Glass, Metals, Ceramics

A new adhesive expressly designed for binding silicone rubber to itself and to glass, metals and ceramics has been developed by the *General Electric Co.*, Pittsfield, Mass.

Known as G-E Adhesive No. 12509, the new type bonding agent, possessing properties similar to silicone rubber, remains flexible and resilient over temperatures ranging from –70 F to 520 F and withstands continuous temperatures of 300 to 350 F in a dry air circulating oven. It can also be used to bond glass to glass, glass to metals, and metals to metals.

The new adhesive has proved especially useful in securing silicone rubber door gaskets directly to oven doors eliminating the need for clamps and bolts. It is also effective for joining the ends of extruded cured stock to form O-ring gaskets of uniform thickness. Previously these gaskets had to be made by molding the loose ends of uncured stock together in a press, causing one portion of the ring to be smaller than the rest.





EFFICIENCY SIMPLIFIED

SPEED production, reduce costs and simplify operations with a compact Detroit Rocking Electric Furnace. Melting takes place in a closed chamber and heat, atmosphere, and composition are *controlled efficiently by one man.* This simplified operation assures a uniformity in the chemical composition of the metals melted, *speeds production and reduces costs.*

Detroit Electric Furnaces being electrically fired *assure uninterrupted production and are dependable,* melting both ferrous and non-ferrous heats in 'round-the-clock schedules. Detroit Electric Furnaces occupy minimum floor space. They operate cleanly and are economical in power consumption. Many models are designed for quick change of shells.

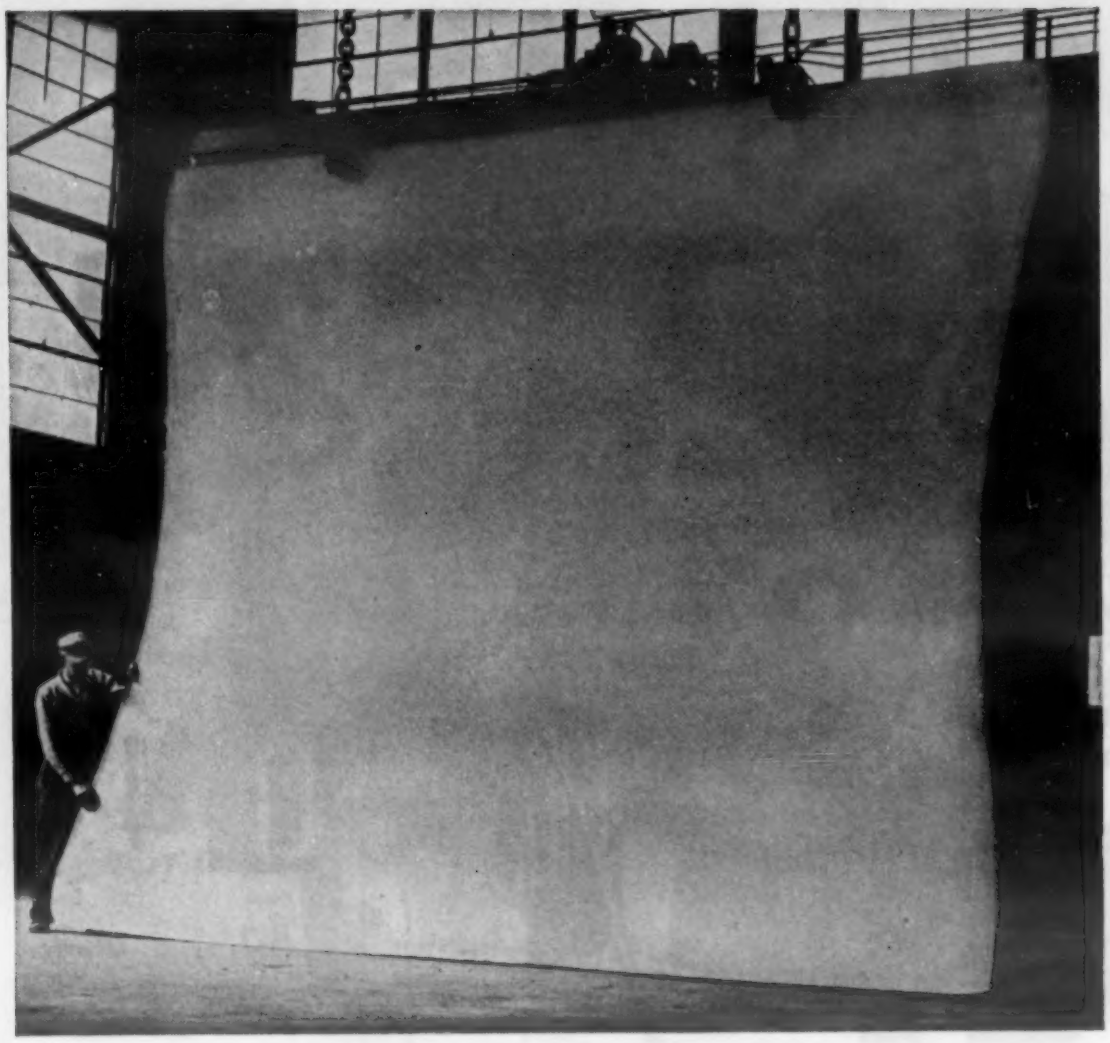
Available in various models with capacities ranging from 10 pounds to 8000 pounds. Send us details of your melting problems and *we can show you how* a Detroit Electric Furnace will *speed production and lower costs* in your operation.



DETROIT ELECTRIC FURNACES

DETROIT ELECTRIC FURNACE DIVISION • KUHLMAN ELECTRIC COMPANY • BAY CITY, MICHIGAN

FOREIGN OFFICES: BIRLEC LTD., Birmingham, England, Representative for Europe and British Commonwealth excluding Canada. EQUIPAMENTOS INDUSTRIAS "EISA" LTD., Sao Paulo, Brazil, Representative in Brazil. M. CASTELLVI, INC., 150 Broadway, New York 7, N. Y., Representative in Chile, Argentina, Peru, and Venezuela. CASA COVACEVICH, Mexico City, D. F., Mexico.



When CARLSON Says LARGE STAINLESS PLATE We Mean LARGE!

This type 304 Stainless Steel plate measures 203" x 168" x ½", to be pattern cut to customer specifications in the Carlson plant.

Produced to chemical industry standards of quality, this plate, weighing 5,180 lbs., is a typical example of the ability of G. O. Carlson, Inc. to meet your needs in a wide variety of stainless analyses.

Remember too, that Carlson can supply you as readily with stainless plates, forgings, billets, sheets, bars, rings, etc. in ANY SIZE, small or large, pattern cut if you desire. Most orders can be filled right out of stock.

When it's Stainless GO to CARLSON first.



Do you receive the G. O. Carlson, Inc. weekly stock list? If not drop us a line. No obligation.

G. O. CARLSON, INC.

Stainless Steels Exclusively

200 MARSHALTON ROAD, THORNDALE, PA.

X-Ray Gage Controls Sheet Thickness

To solve the thickness gaging problem in modern high-speed rolling mills, the *Westinghouse Electric Corp.*, Baltimore, Md., has introduced an X-ray thickness gage. Unique advantages of this gage are (1) no contact with the material being gaged, (2) ready access to areas never gaged before, and (3) high sensitivity and accuracy. As a quality control instrument, this equipment is expected to find application in the thickness control of hot metal and glass sheet, aluminum foil, plastics, paper and other sheet and strip materials.

Employing two X-ray sources at right angles with one photo multiplier-fluorescent screen pick-up unit at the apex, the gage compares the controlled material to a correct sample. Positive and negative readings showing the thickness differential above or below the standard sample are shown on an instrument within view of the operator.

The indicator needle on the gage equipment will react to variations of 0.0001 in. in a 0.1-in. thick sheet and is unaffected by fluttering of the sheet, surface coatings such as lacquer, or by atmospheres heavy with palm oil, steam and water. Normally mounted on a slide so that it can be removed from the pass line, the gage can also be arranged to rove across the sheet.

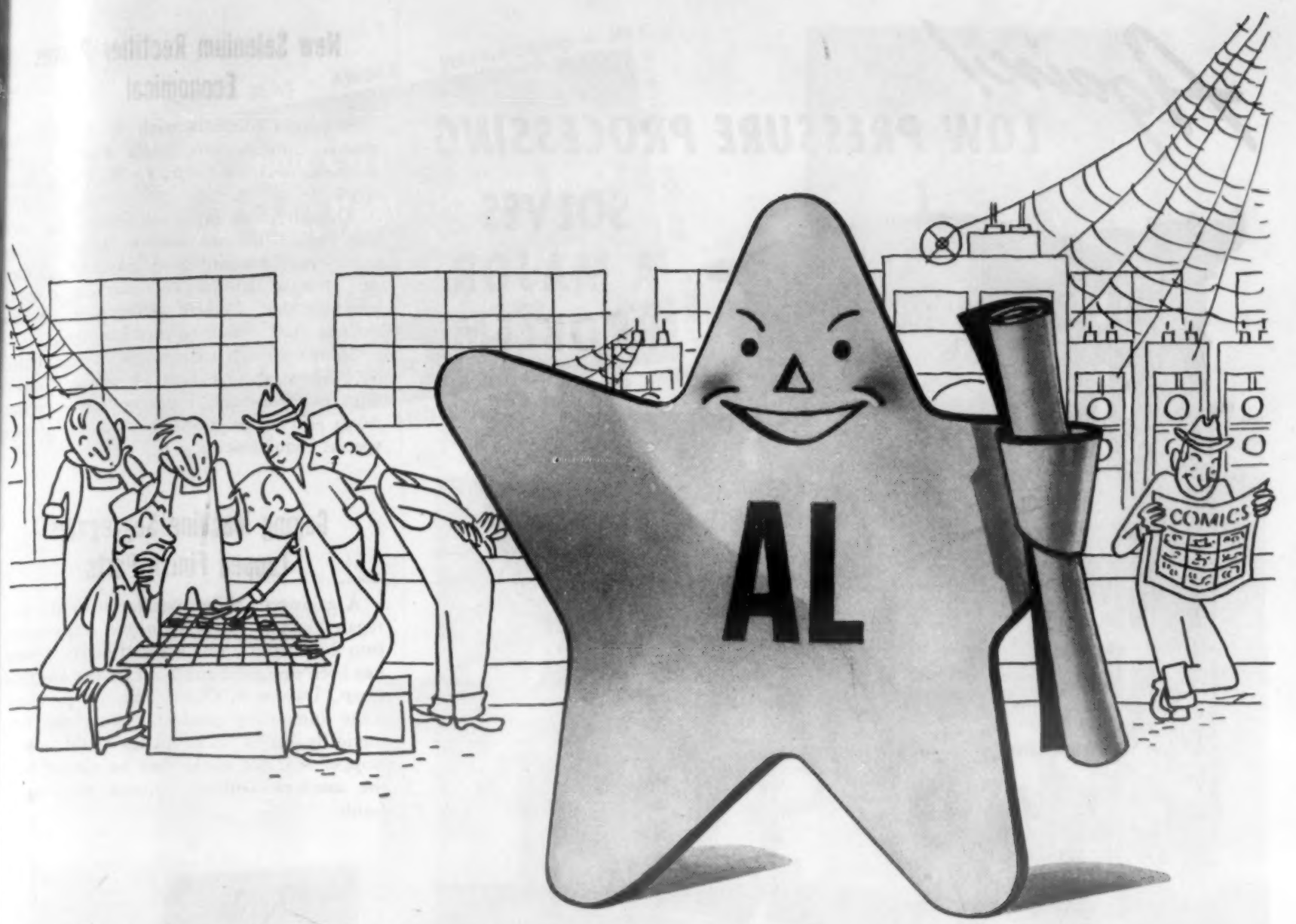
● A new drill press offered by the *Canedy-Otto Mfg. Co.*, Chicago Heights, Ill., offers an infinite range of speeds between 150 and 3400 rpm. This infinitely fine adjustment of spindle speeds allows for a more precise adjustment to the material being worked, thus resulting in increased operating efficiency and drill life.

New Plastics Offer Better Properties

A new series of plastics, Geon Resins 204 and 205, are in commercial production at the *B. F. Goodrich Chemical Co.*, 400 S. Main St., Akron, Ohio. These new materials possess increased thermoplasticity, lower softening points and greater solubility than Geon Resins 202 and 203, which have been standard items of production for several years. Another Geon Resin, 200X14, is available in experimental quantities.

Injection or compression molding materials require the thermoplasticity of these resins coupled with their flow properties at processing temperatures. Their good solubility also makes them highly useful in the solution coating field. Records made from Geon 205 possess an extremely low noise level, high fidelity in reproduction and excellent wear resistance.

Another interesting application is in the molding of rigid sheeting of the type used in playing cards and advertising novelties. The manufacture of battery separators, industrial lacings, rigid piping and heat sealable name tapes are other possibilities.



Battling a shortage of materials?
Allegheny Metal, the pioneer Stainless Steel, will win new competitive advantages for you—perhaps at little or no added cost. And you can get Allegheny Metal promptly—the supply has kept pace with the demand.

Complete technical and fabricating data—engineering help, too—yours for the asking.

ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

Pittsburgh, Penna. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses

Again!

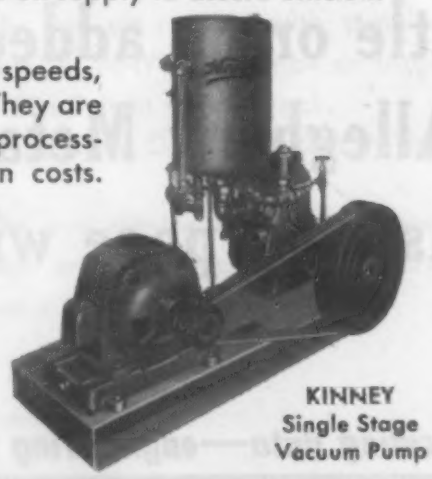
LOW PRESSURE PROCESSING SOLVES A MAJOR PROBLEM



KINNEY HIGH VACUUM PUMP

One of the newer applications of Kinney High Vacuum Pumps is the automatic vacuum treating of sealing oil used in the hydrogen cooling system of large turbine generators. Here, the low pressure treatment constantly removes water and entrained gas from the vital oil supply to assure efficient sealing of the hydrogen system.

For compactness, reliability and high pumping speeds, Kinney High Vacuum Pumps are unsurpassed. They are serving countless industries where low pressure processing simplifies operations and cuts production costs. Among their better known applications are exhausting lamps and tubes, sintering alloy metals, coating lenses, dehydrating foods, producing drugs, etc. Kinney Single Stage Vacuum Pumps produce low absolute pressures to 10 microns; Compound Pumps to 0.5 micron.



KINNEY
Single Stage
Vacuum Pump

Write for Bulletin V45

KINNEY MANUFACTURING COMPANY

3523 WASHINGTON ST., BOSTON 30, MASS.

New York • Chicago • Philadelphia • Los Angeles • San Francisco

FOREIGN REPRESENTATIVES

GENERAL ENGINEERING CO. (RADCLIFFE) LTD., Station Works, Bury Road, Radcliffe, Lancashire, England
HORROCKS, ROXBURGH PTY., LTD., Melbourne, C. 1. Australia
W. S. THOMAS & TAYLOR PTY., LTD., Johannesburg, Union of South Africa

WE ALSO MANUFACTURE LIQUID PUMPS, CLUTCHES AND BITUMINOUS DISTRIBUTORS

New Selenium Rectifier Proves Economical

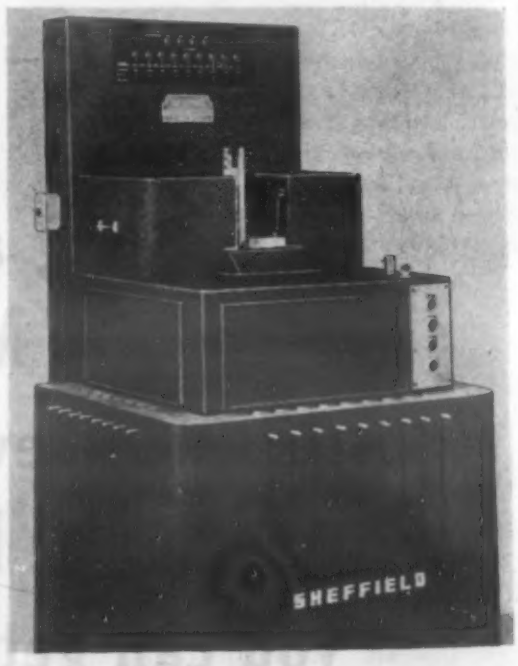
Selenium rectifiers with 36 position tap switch controls are being made by the *Richardson-Allen Corp.*, 15 W. 20 St., New York.

Though these tap switches do not have the perfect minute settings possible with some other Richardson-Allen controls, they do offer a definite economy in original purchase that is advantageous to those who do not need extremely fine settings.

Standard units are designed generally for 36-position voltage taps (6 coarse, 6 fine) with two controls. Finer voltage steps for 60 or 100 tap positions are available to meet special requirements.

Gaging Machine Segregates Lapped Finish Parts

A gaging machine that automatically segregates lapped finish parts for refrigerators into 27 classifications without marring them has been designed and built by the *Sheffield Corp.*, Dayton 1, Ohio. The job presented some interesting problems since the hermetically sealed valve plates could not be hopper fed, nor could they be ejected from the machine without ruining the surface finish.



At 100% efficiency, the gaging machine above inspects 3000 refrigerator valve plates per hr.

Valve plates, about the diameter of a half-dollar and twice as thick, are hand fed into the vertical loading stack. A motor driven slide pushes the bottom plate from the stack into gaging position. By means of airflow jets and the exclusive Sheffield Airlectric gaging heads, the plates are checked and segregated into three 0.0004-in. major classifications of diameter. Each of these three major classifications is further checked and segregated into light acceptable 0.0003-in. classifications of thickness.

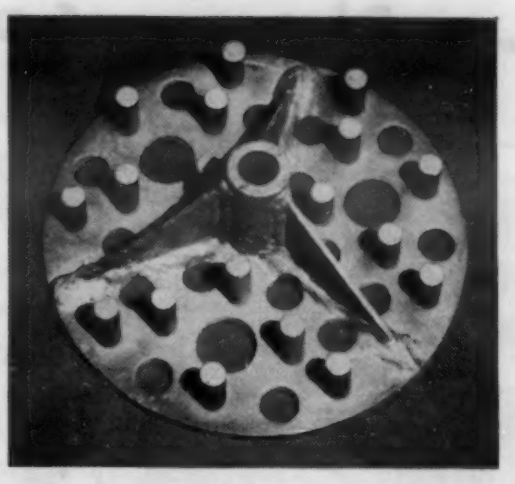
Rejected parts are segregated as follows: undersize on diameter and thickness, salvage oversize on diameter, and salvage oversize on thickness. Rate of inspection is 3000 plates per hr. at 100% efficiency.

SHEET · BAR · ROD · FLAT · ANGLE · HALF-ROUND · HEX · WIRE · ROUND · SHEET ·

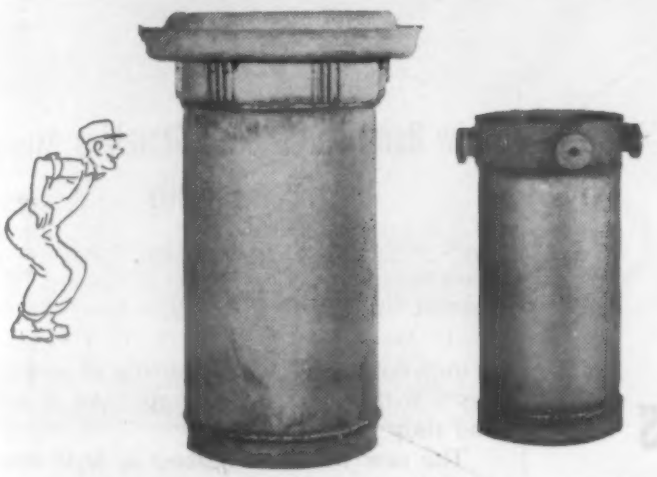
How shall I Use Inconel To Make the Best Heat-Treating Rack?

There are as many answers as there are standard mill forms of Inconel*
HERE ARE A FEW...

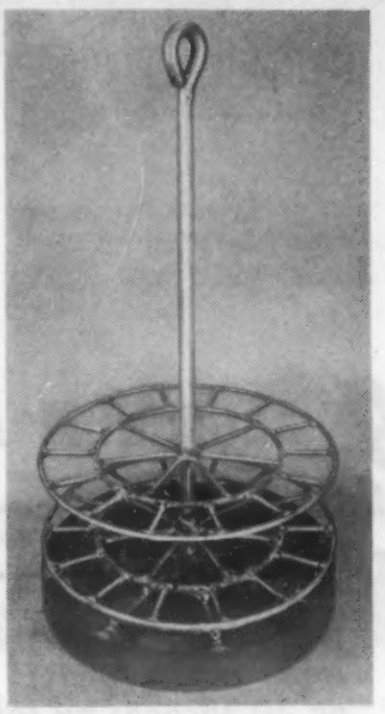




1. IMPOSSIBLE? Not with *Inconel* mill forms! This fixture was built to replace a more complicated design for high temperature tool treating. The fabrication, which seemed impossible at first, was accomplished by using a combination of *Inconel* rod, sheet, and tubing. The maker was Brown-Hutchison, of Detroit, Michigan.

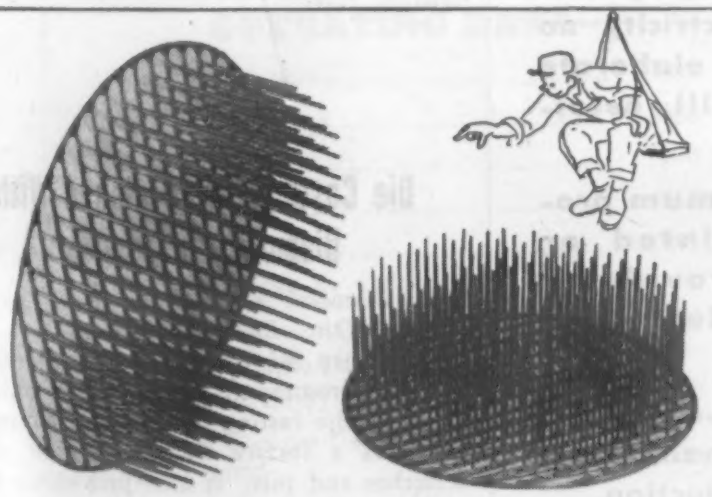


2. 50% MORE LIFE! That is what the user of these fabricated *Inconel* retorts and work baskets reports. The baskets were made of $\frac{3}{16}$ in. *Inconel* sheet, with rolled *Inconel* plate for the sides. The grids were made reversible to extend their life. The Standwood Corporation of Chicago, Illinois, was the fabricator.

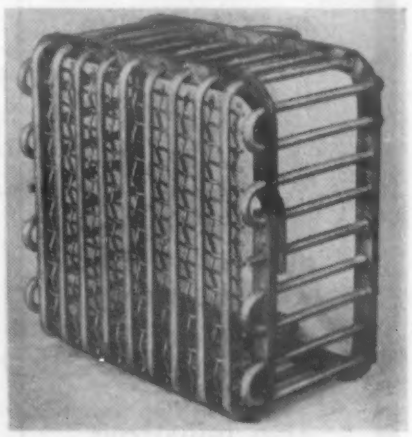


3. HEAT TO 1600°F., THEN WATER-QUENCH. Repeated again and again, this is hard usage for any piece of equipment. But this heat-treating rack, made of *Inconel* rod, successfully withstands these shock extremes of temperature. It holds twenty-one 2.7 in. diameter by 8 in. long shafts for heat-treating in an electric pit furnace with controlled carburizing atmosphere. The round rod construction, with relatively small contact area, keeps shaft distortion to a minimum.





4. MAXIMUM PAY LOADS. The welded *Inconel* rod construction of these carburizing basket fixtures materially reduces the weight, permitting larger "pay loads" to be carried in the furnace. The racks are laid on the bottom of carburizing baskets and loaded with miscellaneous bars and tubes. The fixtures are 27 in. by 7 in., and 21 in. by 6½ in., with $\frac{3}{16}$ in. diameter pins placed on 1½ in. and 1¼ in. centers respectively. They were fabricated by Rolock, Inc., of Fairfield, Conn.



5. LONG SERVICE... HEAVY LOADS. *Inconel* mill shapes, plus flexible construction to allow free expansion, give this carburizing basket unusual length of life. It is 13 in. by 13¼ in. by 9¼ in. over-all. Its weight is approximately 25 pounds. Rolock, Inc., of Fairfield, Conn., was the fabricator.

Whenever you plan new heat-treating racks, remember that *Inconel's* standard mill forms will simplify design problems and insure superior performance. Write today for your copy of: "Inco Nickel Alloys for Long Life in Heat-Treating Equipment."

INCONEL* (80 NICKEL - 14 CHROMIUM)

EMBLEM OF SERVICE INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

*Reg. U. S. Pat. Off.

Picture of Progress



Immersion ALODIZING of aluminum aircraft parts for increased corrosion resistance and lasting paint adhesion

Photograph by courtesy of Stinson Division, Consolidated Vultee Aircraft Corporation, Wayne, Michigan.

Alodizing ALUMINUM ASSURES CORROSION RESISTANCE -- TOUGH PAINT BOND -- DURABILITY -- BEAUTY

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING

Granodine *
Duridine *
Alodine *
Lithoform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING

Deoxidine *
Peroline *

PICKLING ACID INHIBITORS

Rodine *®

The new ACP process using "Alodine"* takes but 2 minutes by immersion—or 30 seconds by spray in a power spray washer. No electricity—no high temperatures—no elaborate equipment—no special skill, necessary.

"Alodine" imparts maximum protection to either painted or unpainted aluminum—provides a durable bond for tenacious finish adhesion.

Alodizing is simple, effective and economical—in large or small, intermittent or continuous production. Additional data available on request.

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

Die Caster for Zinc and Aluminum

A new model die casting machine for both zinc and aluminum, called the Two-Pounder, has been announced by *DCMT Sales Corp.*, Beach 79 St. at Bay, Rockaway Beach, N. Y. Aluminum can be cast as rapidly as zinc with this machine. The production rate for each metal is about 350 shots per hr.

Among the features claimed for the machine is the fact that the change-over from zinc to aluminum die casting can be made without the use of the hand ladle for each shot in aluminum. The capacity is 2 lb. on zinc and 1 lb. on aluminum, on 12 by 18-in. standard die blocks.

There are no tie bars through the die blocks, which leaves all four sides open for core pulls or placement of inserts. The die carrier slides on dovetail ways. Still another advantage is that this machine is completely pneumatically operated, and controlled entirely from one toggle switch.

New Hand Torch Cuts Stainless Steels Economically

A newly designed hand torch for cutting stainless steels has been placed on the market by the *Air Reduction Sales Co.*, 60 E. 42 St., New York 17, N. Y. This torch brings economical flame cutting of stainless steels within the scope of all types of mill and shop operations.

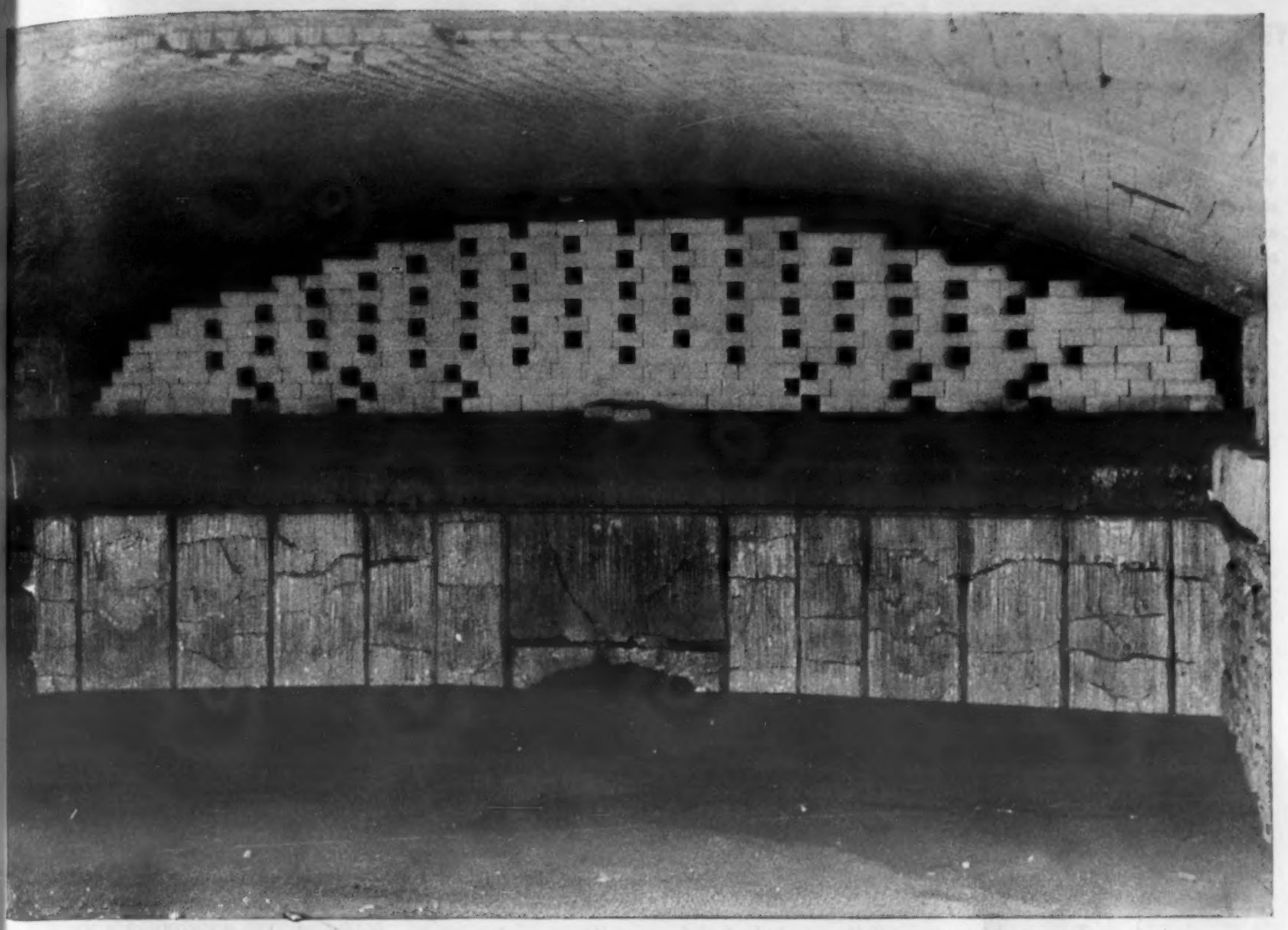
The new torch, designated as Style 9016, uses the Airco flux injection process. It is available in 21-in. and 36-in. lengths with a 90-deg. torch head. Prior to sales announcement, it was subjected to extensive field trial. Because of the resemblance in design to the Airco Series 9000 torches, standard parts will often be adaptable in torch repair, thereby minimizing maintenance costs.

Die Casting Dies Finished With Diamond Compounds

A diamond compound, made by the *Hyprez Div., Engis Equipment Co.*, 431 S. Dearborn St., Chicago 5, Ill., is rapidly gaining prominence in finishing and refinishing die casting parts. This compound produces a surface that is free of nicks, scratches and pits. It also provides a high mirror polish in the die cavity.

The abrasive content of Hyprez diamond compounds consists of clean, virgin, accurately-graded diamond powders uniformly distributed and permanently suspended in a patented stable compound. It is applied to the surface of the dies by a specially designed applicator gun.

Other recommended applications for this compound are for lapping of leader pins, bushings and inserts. Accurate, smoothly lapped and polished surfaces on moving die parts insures good performance, greater accuracy and extended life.



Good Design, Good Operation
Good Refractories, Good Results!

OPERATING DATA

Sq. Ft. Melting Area	585
Total Operating Days	626
Idle Days	190
Total Days (Life)	816
Tons of Glass Melted	86659.1
Tons Glass per Sq. Ft. (ME) for Total Life	148.1
Sq. Ft. per Ton per Day (Operating Days)	4.22
Sq. Ft. per Ton per Day (Total Life)	5.5
Tons Coal Used	31085
Tons of Coal Per Ton of Glass (Total Life)	.359

The photograph above shows the bridgewall and throat of a continuous tank which recently completed a campaign on flint bottle glass.

This well designed and well operated tank, constructed with Corhart Zed sidewalls, Corhart Zac bridgewall and throat and Corhart Standard working end walls, set an all-time production record for its operator.

The operating data at the left gives you the interesting part of the story.

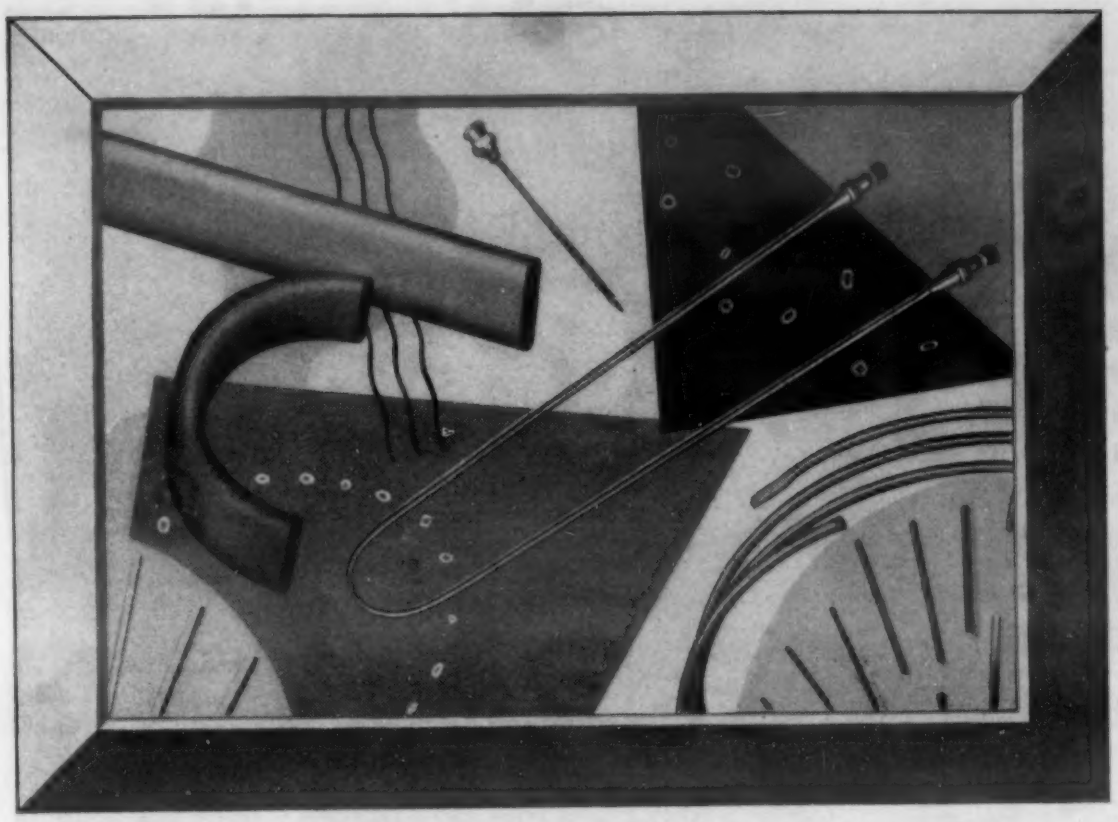
Good refractories such as Corhart Electrocast cannot do the job alone, but they play an important part in the success of any glass tank campaign.

We'll be glad to discuss your refractory problems with you. Corhart Refractories Company, Incorporated, 16th and Lee Streets, Louisville 10, Kentucky.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

The words Corhart, Zed and Zac are Registered Trademarks.



MODERN

ART

To produce small metal tubing with a clean, bright finish, close dimensional control, uniform physical and metallurgical properties to your exact specification is a highly developed art in which Superior excels.

You can depend upon Superior tubing.

THE BIG NAME IN SMALL TUBING Superior (.010" to 5/8" O.D. MAX.)

SUPERIOR TUBE COMPANY
2006 Germantown Ave.
Norristown, Pennsylvania

For Superior tubing on the West Coast, call PACIFIC TUBE COMPANY, 5710 Smithway St., Los Angeles 22, Cal. ANgeles 2-2151

Zinc Black Solution Improves Surfaces

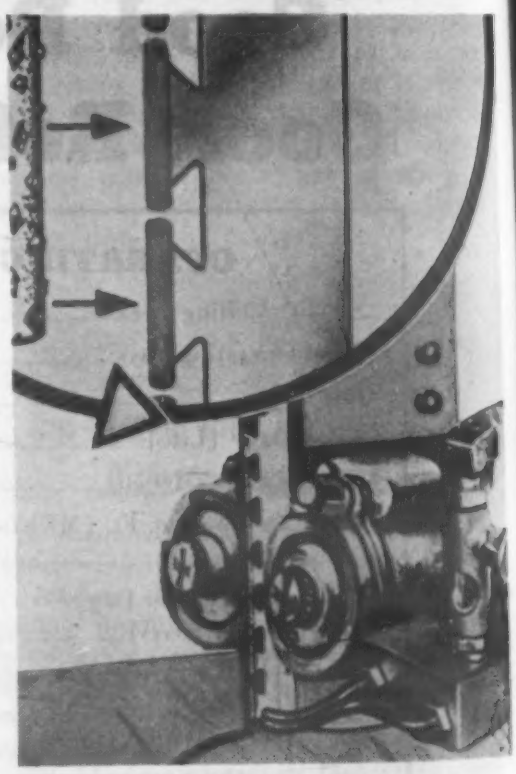
Many desirable characteristics are imparted to zinc plate, zinc alloy die castings and cadmium plate by immersion in Black Magic zinc black recently introduced by the *Mitchell Bradford Chemical Co.*, 2446 Main St., Stratford, Conn.

Immersion in the zinc black solution results in a chemical reaction with the zinc or cadmium surfaces which produces a glossy black finish. Immersion time is short: 1 to 2 min. for zinc and zinc alloys, 3 to 5 min. for cadmium plate.

In addition to providing an attractive black finish for such products as toys, machine parts, recorders and cameras, Black Magic is also an excellent base for paint and enamel finishes. It possesses a high degree of abrasion resistance and is now being used as a finish on moving parts or parts which are subject to constant pressure or abrasion. Excellent resistance to most alkalis, acids and organic solvents is another feature of this product.

Diamond Bandsaw Cuts Hard Metals, Vitreous Materials

Diamonds, regarded as the hardest material known, have been bonded in a sintered tungsten alloy matrix and electronically brazed to teeth segments in a specially designed saw band by the *Do All Co.*, Des Plaines, Ill. This innovation thus permits contour cutting of hardened tool steels, tungsten carbides, stone and vitreous materials directly to a layout line with precision comparable to conventional contour sawing.

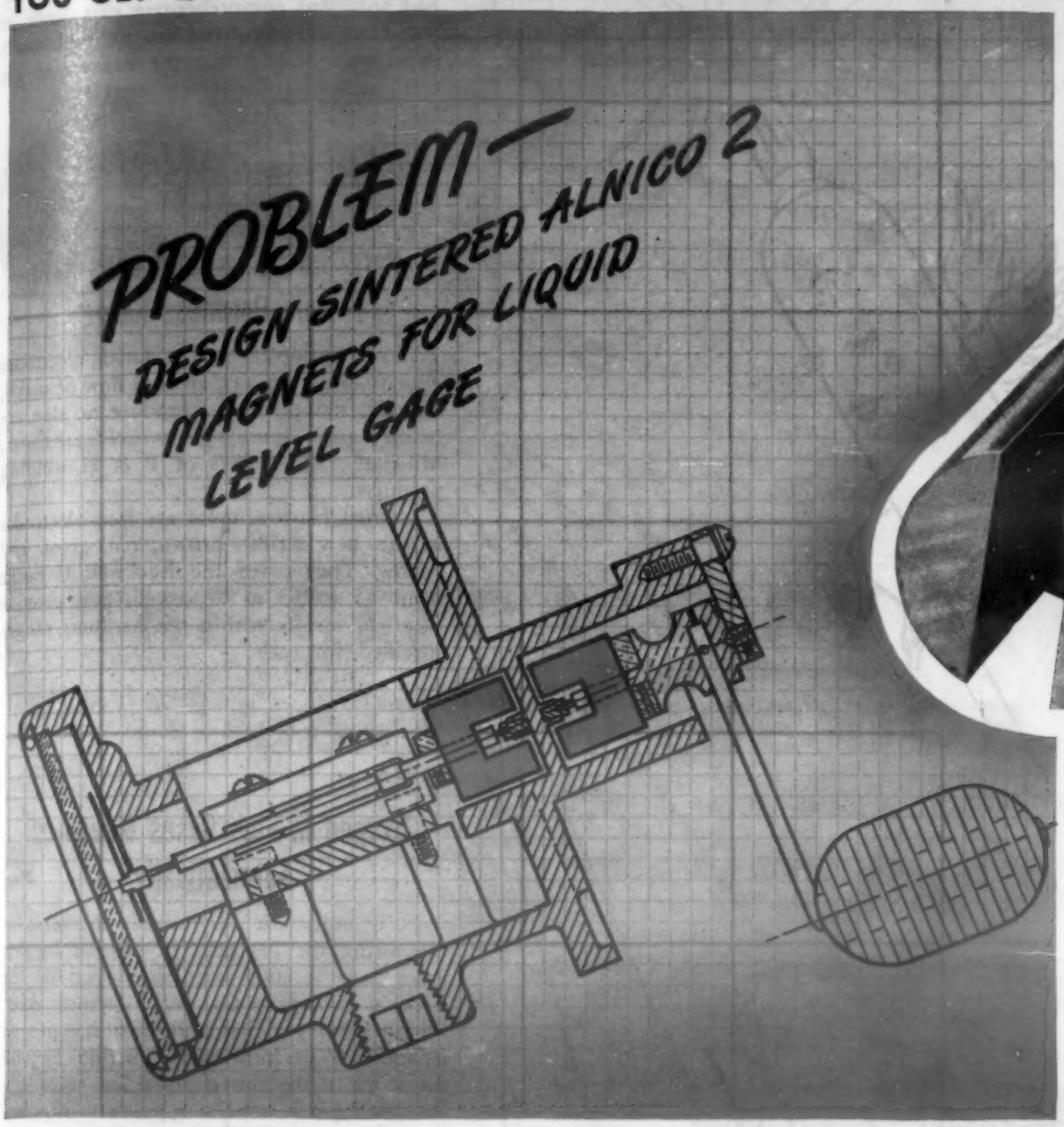


The diamond impregnated segment above is electronically brazed to the steel band.

Sawability tests which have been performed on a variety of materials indicates that an entirely new field has been opened

(Continued on page 140)

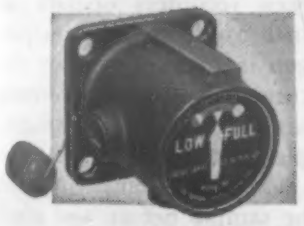
YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS



Here's another outstanding application for one of the many G-E permanent magnet materials —the magnetic liquid level gage manufactured by The Boston Auto Gage Company.



The Magnets that Guard your Transformer



Two G-E sintered ALNICO permanent magnets, separated by an aluminum diaphragm, function as a leakproof magnetic coupling in this gage to accurately indicate the level of the insulating liquid in transformers. The rise or fall of the float actuates the dial pointer by means of the coupling.

In addition to the large group of sintered and cast ALNICO permanent magnets, General Electric now offers you greater flexibility of magnet design with the ductile alloys CUNICO, CUNIFE and SILMANAL and the lightweight, non-metallic VECTOLITE. Be assured of receiving magnets of the highest uniform quality resulting from precise G-E production methods, accurate testing and rigid inspection.

Let us help you with your magnet application problems. General Electric engineers, backed by years of research and magnet design experience, are at your service. *Metallurgy Division, Chemical Dept., General Electric Co., Pittsfield, Mass.*

SEND FOR our new bulletin, CDM-1, "G-E Permanent Magnets", specifically designed to help you with your permanent magnet problems.
This bulletin contains information about the characteristics and properties of G-E permanent magnet materials, their application and design.



METALLURGY DIVISION, Section CN-3
CHEMICAL DEPARTMENT
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.

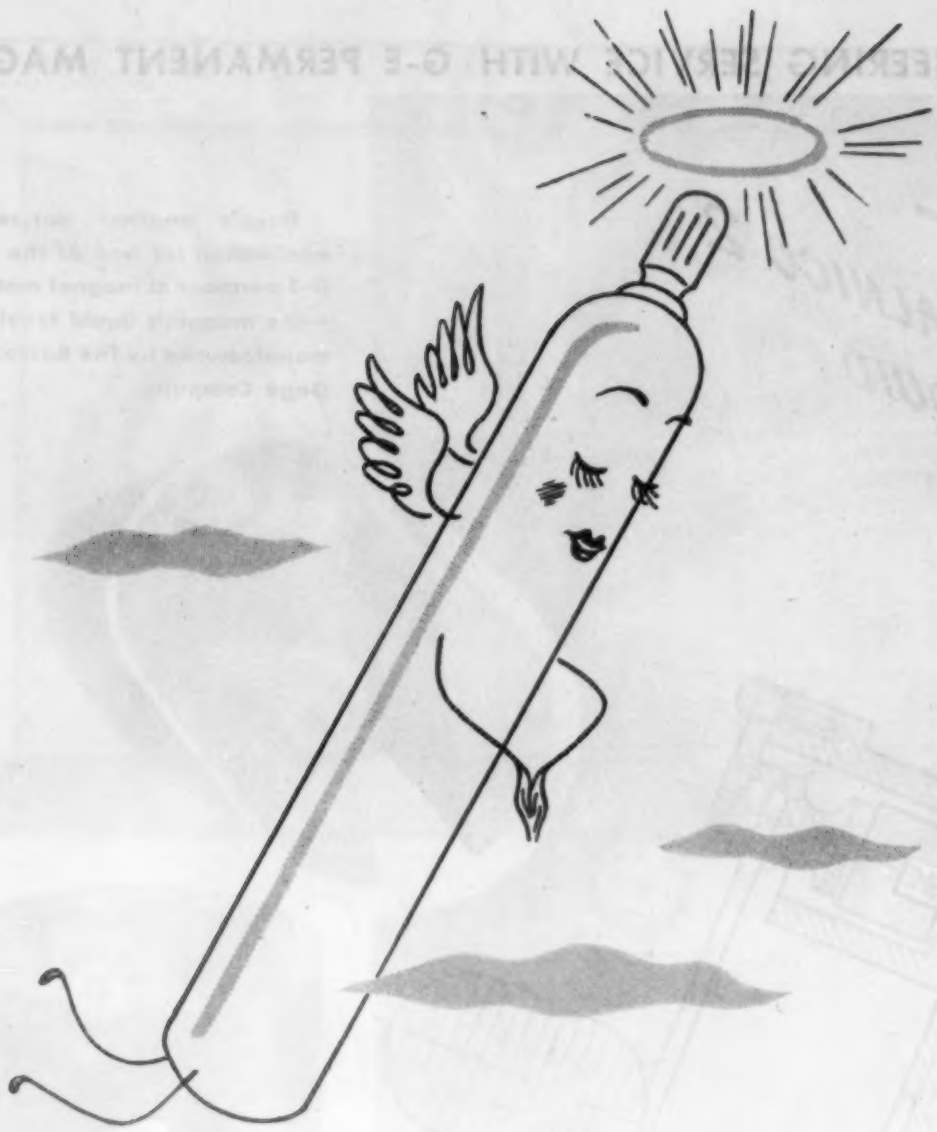
Please send me your new bulletin, CDM-1, "G-E Permanent Magnets".

NAME..... TITLE.....
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ADDRESS.....
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PERMANENT MAGNETS

GENERAL ELECTRIC

CD47-3 AB



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Purity is bred into Mathieson Ammonia. We purge every trace of foreign element from its forebears—nitrogen and hydrogen—then combine these gases into the purest ammonia obtainable.

And do you think we stop there? Not by your pyrometer! Cylinders are thoroughly checked before each shipment. Valves get a special going over. And as for moisture, non-condensable gases and other impurities—they're ushered coldly out. Prompt deliveries of that good Mathieson Ammonia in 100- and 150-lb. cylinders from any of 44 warehouses. Write for free 40-page booklet: "Ammonia in Metal Treating." The Mathieson Alkali Works (Inc.), 60 East 42nd Street, New York 17, N. Y.

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for successful application of the band sawing principle. However, since no one has had sufficient comprehensive experience in this new phase of band sawing, each user's experience will dictate the answers to his own particular fabrication problems.

Hard Surfacing Electrodes Have Wide Hardness Range

A new group of hard surfacing electrodes which feature a quiet, smooth flow of metal, an easy, stable arc and produce no slag are being manufactured by *Harnischfeger Corp.*, Milwaukee, producers of P & H welding products.

Named Hartop, there are four electrodes in this new series—brown, red, green and yellow. They cover the Rockwell C range from 35 to 63 as deposited, and provide excellent results within the hardness ranges specified for each.

Oxygen in Flue Gases Measured Automatically

Fully automatic Micromax recorders for measuring the per cent of oxygen in flue gases have recently been developed by the *Leeds & Northrup Co.*, 4911 Stenton Ave., Philadelphia 44. This equipment has proved its ability to perform many functions beyond the scope of the conventional gas recorders. Essentially, it is used as a guide to regulate the amount of excess air in furnaces such as glass tanks, cement kilns and open hearths where carbon dioxide is evolved by process reactions.

Micromax oxygen recorders operate on the reliable thermal conductivity principle. Analysis for oxygen is accomplished by the sensitive and accurate hydrogen difference method. This consists of adding hydrogen to the gas sample, removing oxygen by combustion, and electrically comparing the conductivity of the sample before and after oxygen is removed. Since all parts which contact the gases are made of glass, the equipment is corrosion proof and stable in calibration.

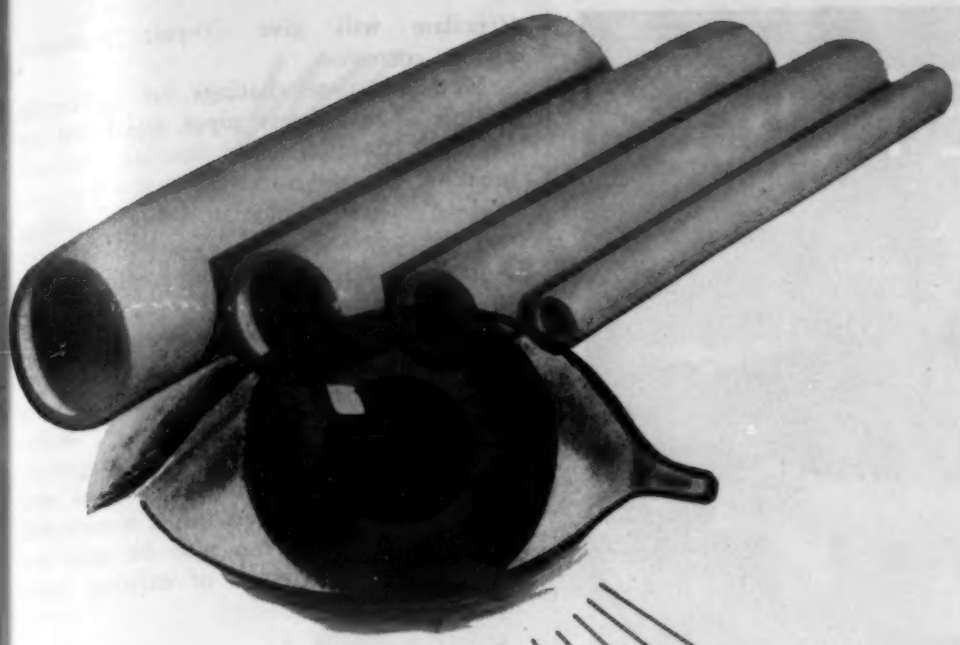
Two models of this instrument are manufactured. The round chart model is designed for extra visibility of scale, while the strip chart model is for highly detailed record purposes.

New Coatings Are Corrosion Resistant

Two new types of anti-corrosive coatings, which will air-dry without baking, have been announced by *Industrial Metal Protectives, Inc.*, Dayton 2, Ohio.

Accelerated laboratory tests indicate that

(Continued on page 142)



THE REFRACTORY *looks* AT THE JOB

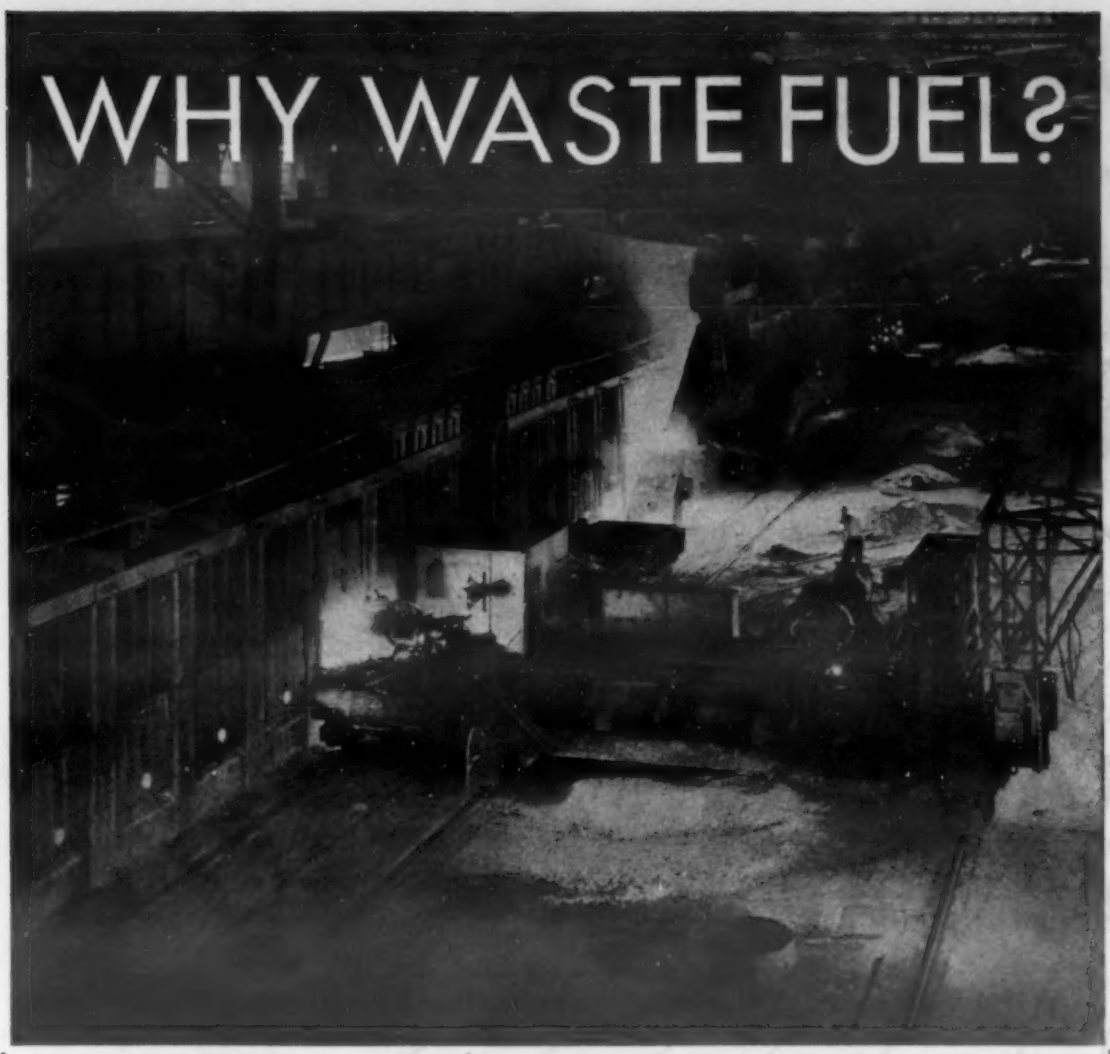


FURNACE operations which today often demand a refractory tube able to withstand high temperatures and to give long, economical service, are looked upon by Norton Company as the logical application of the new "Pure Oxide Refractories". ALUNDUM* furnace tubes, which are essentially sintered alumina without any bond, do provide greater refractoriness and much longer life and thereby greatly extend the utility of the furnace tube line of Norton Refractories.

NORTON COMPANY
Worcester 6, Massachusetts

* *ALUNDUM — Trade-mark Reg. U. S. Pat. Off.*

NORTON REFRACTORIES



Therm·O·flake *prevents waste*
BY REDUCING HEAT LOSSES...

MORE THAN 25% of Open Hearth fuel can be wasted through heat lost through brickwork and heat absorbed by cold infiltered air.

Therm·O·flake INSULATIONS are designed to reduce heat losses and seal furnace walls against cold air infiltration. These are used regularly on hundreds of open hearth furnaces and save steel producers thousands of fuel dollars daily.

Therm·O·flake ENGINEERS will prepare an accurate fuel economy survey of existing furnaces in your plant and submit complete thermal data and recommendations for safe maximum insulation of any open hearth furnace, on request.

Illinois Clay Products Company
JOLIET, ILLINOIS

Exclusive Manufacturers of
Therm·O·flake
open hearth Insulation

Zincilate will give 20-year protection against corrosion.

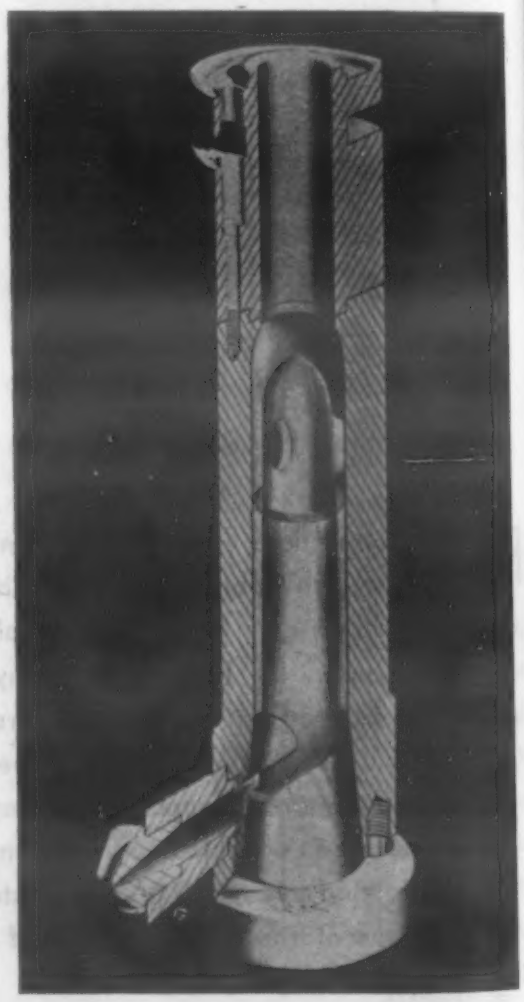
New Zincilate coatings are sufficiently flexible so that sheets, pipes, and forms can be bent double, after coating, without breaking the protective coating. Over-coatings of enamel, paint or wrinkle finishes may be applied over "Zincilate" after 5 min. of air drying, and both coatings baked at the same time.

Zincilate is adaptable to production line application by dipping, spraying, brushing or roller coating, with conventional finishing equipment. It has been adopted by manufacturers of air conditioning equipment, bakery equipment, automotive parts and assemblies, valves, sheets, pipe, screens and other products. It can also be used for maintenance and repair of existing structures.

More Intricate Designs Molded With New Injection Cylinder

A plastic molding press injection cylinder with independent temperature control in its spreader and a completely annular material passage has been perfected by *Lester-Phoenix, Inc.*, Cleveland, Ohio. This cylinder is an outgrowth of original experiments with internal heating of the spreader.

Through this new development, designed as a general purpose cylinder for all thermo-plastics including vinylite and nylon, it is now possible to mold larger pieces on more intricate molds. Due to the excellent plasticising ability of this design, less power is required for heaters. Maintenance cost is reduced and production is increased.



Shown is a schematic cutaway drawing of the new Lester-Phoenix injection cylinder.

When Steel Parts Must Be

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COLD DRAWN ALLOY STEEL BARS

Here are all the well-known advantages of Republic Alloy Steels—including (1) *high strength,* (2) *toughness* and (3) *hardenability*—the qualities that enable steel parts to last longer and cut costs where wear, strain and shock are severe.

Here, too, are all the advantages of Republic Union Cold Drawn Steels—(1) *close tolerance,* (2) *accuracy of section,* (3) *fine surface* and (4) *UNIFORM MACHINABILITY*—the qualities you need to produce high quality steel parts at lowest possible unit cost.

Republic Cold Drawn Alloy Steel Bars are available in all popular analyses, in standard shapes and sizes, and furnace treated (annealed, normalized, spheroidized, stress relieved or carbon corrected) as you desire. And Republic metallurgists are ready to help you get the results you need. Write for further details.

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Export Department: Chrysler Building, New York 17, New York

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Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Plates, Pipe, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Profits Begin Here . .



When carloads of sheet stock are unloaded at the receiving room, actual manufacturing costs begin. But, when sheet stock is unloaded and carried into storage or to machines with C-F Sheet Lifters, these costs are minimized — stock damage is eliminated and your end profit begins. Because C-F Sheet Lifters, under one man end or remote cab control, handle more sheets per load, safer, faster and more economically, they are the logical answer to the demand for modern, low cost materials handling.

There are C-F Lifters in capacities from 2 to 60 tons or larger, in standard or semi-special designs to meet any sheet or materials handling requirement.

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C-F positioned welds mean better, more economical welds

CULLEN-FRIESTEDT, CHICAGO 23, ILL.

ENGELHARD Thermocouples . . .



- ENGELHARD manufactures a complete range of assembled thermocouples consisting of thermo-elements with insulators, protection tubes, terminal heads, couplings and various accessories. Thermo-elements may be platinum vs. 90% platinum 10% Rhodium, Reclaimed Platinum vs. Platinum Rhodium, Chromel vs. Alumel, Iron vs. Constantan and Copper vs. Constantan.
- ENGELHARD assembled Thermocouples insure maximum efficiency from their pyrometer instruments because each is made up from selected individual parts, chosen because of their ability to meet the requirements of a specific application.

Take your Thermocouple problems to ENGELHARD!

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News of...

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Engineers

Dr. *Henry H. Hausner,* research associate, New York University, is consulting engineer with a new company, Micromet, Inc., 60 Park Place, Newark 2, N. J., which produces ultra-fine copper powder. D. Bondareff is president.

Lloyd R. Cooper has been named director of research for Heppenstall Co., Pittsburgh. After graduation from Lehigh University in 1935 he became a metallurgical observer at the Homestead works, Carnegie-Illinois Steel Corp., later working in the U. S. Steel research laboratory at Kearny, N. J. Then he joined Heppenstall-Eddystone Corp. as engineer of tests. In 1944 he moved to Pittsburgh to serve as research metallurgist in the newly-organized research department of the Heppenstall Co., having been appointed acting director of research in 1946.

Walter E. Remmers has been elected president, Electro Metallurgical Co. and other associated metallurgical units of Union Carbide & Carbon Corp. He has been a vice president and director of Electro Metallurgical Co. since 1945. He is a graduate of the Missouri School of Mines and Metallurgy, and took post graduate work in metallurgy at the University of Michigan. He has been with his present company since 1936.

Dr. *Robert J. Anderson* has resumed his consulting engineering practice, specializing in the metallurgy of aluminum and magnesium, being located temporarily at 125 N. Portage Path, Akron 3, Ohio.

Howard Ketcham, New York designer and engineer in consumer and industrial fields, has been retained by the Rigid-Tex Corp., Buffalo, to develop new patterns, textures and color schemes for Rigidized metals and to collaborate with customers on new applications.

N. F. Vanderlipp has been made factory manager, Glenn L. Martin Co., having formerly been general manager and board member of the Bellanca Aircraft Corp. He has introduced modern factory methods into airplane manufacture. He has had experience with some half-dozen aircraft manufacturers.

Hugo E. Johnson, formerly research associate with Carnegie-Illinois Steel Corp., has been appointed to the administrative staff of Battelle Memorial Institute. He will co-ordinate the various research groups concerned with iron and steel metallurgy and

Molded of Celcon, the Durobilt seat is an example of the large size, tough, resilient and non-warping moldings possible with this Celanese *ethyl cellulose* plastic.

In comparison tests with other plastic materials, Celcon was selected because it best met the manufacturer's requirements, including resistance to cleaners, soaps, and antiseptics.

You'll find that Celcon has the qualities that consumer products need. Celcon molds fast, accurately . . . machines without stress crazing . . . holds fast to metal cores and inserts . . . drills without weakening . . . is available in full color range.

Check on Celcon with your Celanese representative. He will tell you what you need to know about this tough Celanese plastic. Celanese Corporation of America, Plastics Division, Dept. D-4, 180 Madison Avenue, New York 16, N.Y.



Molded by Arrow Plastics Corp., Passaic, N. J. for Plastic Appliance Mfg. Corp., 11-13 Maryland Avenue, Paterson, N. J.

Celanese* Plastics

*Reg. U. S. Pat. Off.

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GCC BRAND

Cerium Metal (Mischmetal) GCC Brand contains a high percentage of Cerium Metal—between 50-55% . . . Has a very *low and uniform* iron content—about 1% . . . Is practically free from impurities and enclosures.

This pure and uniform composition—steadily checked by our laboratory—is a very essential factor in many metallurgical applications.

• **Are you seeking to better the metallurgical or mechanical properties of your products?** Our technical staff will gladly investigate how the use of Cerium Metal—GCC Brand—will help improve your metal products. For experimental purposes, we shall be pleased to send you a sample of our Cerium Metal Cubes.

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ENGINEERS COMPANIES SOCIETIES

act in a liaison capacity between the Institute and iron and steel industries. He is a graduate in metallurgical engineering from Ohio State University and belongs to several technical societies. *Richard J. Anderson,* economic geologist, has joined Battelle to study the economics of raw materials. He was geologist for the Alcoa Mining Co. and more recently managing engineer with Raw Materials Survey. He is a member of five technical societies.

George Strottman, for 23 years with the Formica Insulation Co., maker of laminated materials, has been promoted to superintendent of the treating, treated materials, inlay, press and plate department of the factory.

J. Robert Pauline has been appointed works manager, Kellogg Div., American Brake Shoe Co., having formerly been assistant to the vice president in charge of operations and engineering. Prior to 1943 he was with the Burnham Boiler Corp. in Irvington, N. Y. *John A. Fellows* has been made assistant chief metallurgist at Brake Shoe's research center at Mahwah, N. J., having rejoined that company after 2½ years in the atomic energy field with Union Carbide & Carbon Co. He received the degree of Doctor of Science from Massachusetts Institute of Technology in 1942.

Jules Muller has been appointed director of engineering, E. W. Bliss Co., maker of presses, rolling mills and can machinery. He will coordinate engineering among the various product divisions. Mr. Muller previously supervised welding design and manufacture for Bliss machinery. Other company associations have been A. O. Smith Corp., Henry Voght, and Leeds & Northrup.

James G. Walker has been made assistant superintendent, Worcester Pressed Steel Co., being an authority on the construction of tools and dies for stampings. He previously served with Southern Aircraft Corp. and with Consolidated Vultee Aircraft Corp. He has authored several articles in the technical press on stamping techniques, and is co-author with Carl Taylor of a book, "Simplified Punch and Die Making"; also of "Drawing Methods and Formulas," to be published in the near future.

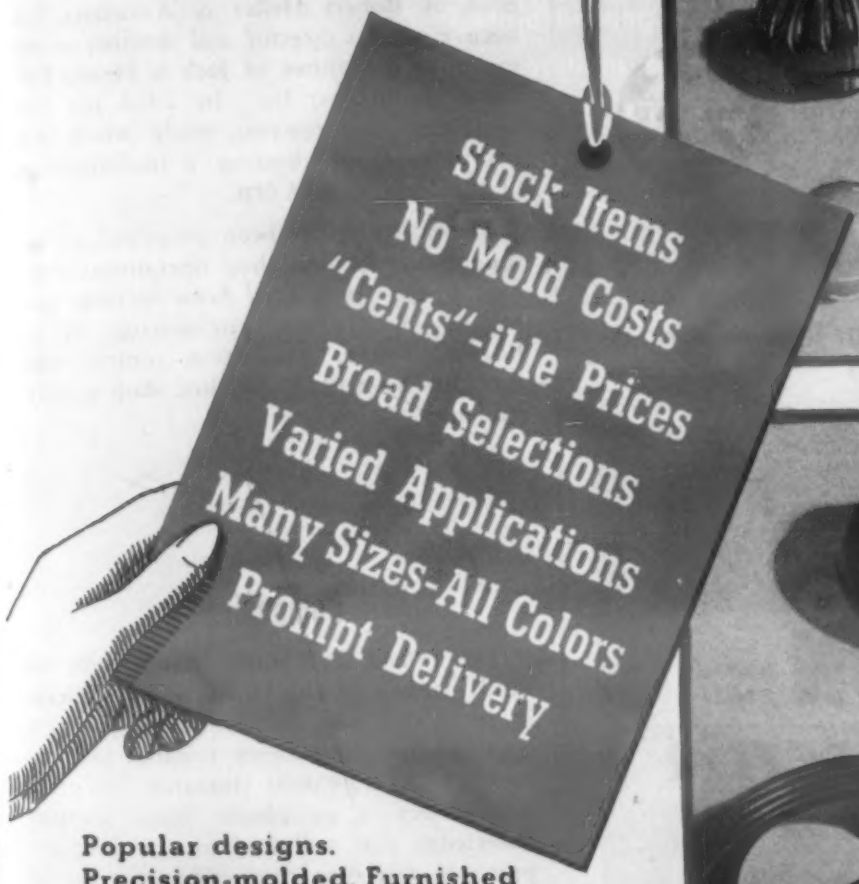
Dr. *Haig Solakian,* for twelve years vice president, chief metallurgist and director of research, A. F. Holden Co., has resigned to become president of John Ek Industries, Inc., Guilford, Conn., engineers and manufacturers.

Robert W. Russell has joined American Cladmetals Co. to carry out the installation program at the company's Carnegie, Pa. plant, the first devoted exclusively to clad metals in this country. Other company affiliations have been with the Jessop and Crucible Steel companies.

Erwin G. Somogyi has been appointed

Handles Knobs Pulls Trims







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High conductivity of electro-cleaning baths which contain Metso Detergents speeds up grease removal. And, under high current density, Metso cleaning baths are stable. With Metso, also, you can be sure of spontaneous emulsification of oils, dispersion in the solution, and this "plus" advantage — protection from the re-depositing of removed dirt.

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. . . acclaimed as the finest machine of its kind. A versatile, precision-made unit, ideally adapted to wax injection into both rubber *and* metal molds . . . can be used as either a hydraulic or air-pressure operated unit.

The BARON Injector

Check these features against any other wax injector on the market:

- **Hydraulic or air-pressure operation**
- **Positive temperature control to within two degrees**
- **Positive pressure control to a fraction of a pound**
- **Complete control over the quantity of wax injected**
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- **Full two-quart capacity**
- **Designed for rapid wax pattern production**
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ENGINEERS COMPANIES SOCIETIES

to the newly-created position of assistant director of research, Plastics Div., Monsanto Chemical Co., in charge of process development. He will direct pilot plant operation, small product manufacture, mechanical development and research engineering.

Roman F. Arnoldy has been elected president and general manager, Houston Heat Treating Co., Houston, Tex., having formerly been a development engineer with Union Carbide & Carbon research laboratories. He is an authority on flame hardening and has written technical articles on that subject.

Robert Heller, industrial designer and head of Robert Heller & Associates, has been elected a director and member of the executive committee of Jack & Heintz Precision Industries, Inc. In 1938 his firm completed a three-year study which was instrumental in effecting a modernization of the U. S. Steel Corp.

Harry Green has been promoted to consultant on machine shop operations of the Falk Corp., while *Carl Senn* becomes consultant on methods engineering. *B. C. Bugbee,* former production control manager, has been made machine shop superintendent.

Companies

The *Inland Steel Corp.* has become the ninth partner of the University of Chicago in its atomic and metal research program. Each partner contributes towards the university's $12,000,000 research program. The object is to obtain basic scientific knowledge that will lead to new products, processes and economies. Members receive advance reports on all phases of research and they participate in quarterly conferences to discuss current progress and techniques.

The *Dow Chemical Co.* has formally released its trademark rights to the name, "Saran," permitting it to become the descriptive name of the product. The action was taken in the interest of simplifying identification on various plastic materials whose chemical names have for years been confusing to press, trade and consumer. Saran applies to thermoplastic resins known as vinylidene chloride copolymers.

The *Ohio Crankshaft Co.* has purchased the *Induction Heating Div., Budd Co.,* at Detroit. The deal includes machinery, equipment, inventories and patents, but not the land or the buildings. Budd Induction Heating, Inc. was formed in September, 1938, as a partially-owned subsidiary of the Budd Wheel Co. to manufacture and sell equipment for the induction heat treating of metals. The *Tocco Div., Ohio Crankshaft,* has established an engineering divi-

ZIRCON INSULATION CEMENT FOR ELECTRIC HEATERS

TAM zircon cement 31568-H has been developed to meet all five major requirements of insulation cements: 1—easy application: 2—refractoriness: 3—certain limiting values to current leakage at operating wattage, under humid conditions; and under an externally applied stress voltage: 4—stability of insulation and structure through a 1000 hour-life test: 5—reasonable cost. Performance indicates an outstanding group of compositions, both electrically and ceramically. The results listed below apply to a particular structure for cement applied in a specific manner. Any variation may alter results.

DRY PRESS FLAT IRON

CEMENT	OPERATING LEAKAGE	HUMIDIFICATION LEAKAGE	RETURN TO NORMAL
31568-H	0.002 M. A.	0.2	15 to 30 seconds

In dry press work insulation thickness is relatively greater than other assemblies which accounts for the very low values obtained.

STRIP HEATERS

Operating Leakage		= 0.002	M. A.
Heater cold stress voltage	700	0.1	M. A.
Heater cold stress voltage	1500	0.7	M. A.
Heater hot stress voltage	700	0.00	M. A.
Heater hot stress voltage	1500	0.4	M. A.

MUD CAST RANGE ELEMENT

Leakage at operating wattage	= 0.055	M. A.
Leakage after humidification	3.2	M. A.

Returns to normal in 15 to 30 seconds after current is turned on.

TAM

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Ajax Plastic Bronze
Ajax Anti-Acid Bronze
Ajax Phosphor Bronze
Ajax Red Brass Ingots
Ajax Manganese Bronze
Ajax High-Tensile Manganese Bronze
Ajax Golden Glow Yellow Brass
Ajax Nickel-Copper 50-50%
Ajax Manganese Copper
Ajax Aluminum Alloys
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Ajax Silicon Copper
Ajax Nickel Alloys
Ajax Phosphor Tin

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NOTE: * "Proper Melting Decreases Foundry Losses," contains interesting data. Also, the booklet, "Non-ferrous Ingot Metals of Today." Write for both. They are free.

Successful foundrymen deoxidize or "clean up" molten metal by a scientific method worth using as indicated:

They use phosphorus . . . expertly . . . in the form of "Ajax Phosphor Copper" . . . added as the crucible is removed from the furnace . . . for virtually all brass and bronze alloys.

In notched waffle sections, or in shot form, Ajax 15% P-Cu does its work at .01% (1 oz. per 100 lbs.). Introduced, and having time to react when stirred with a whirling motion of the skimmer, it causes oxides to rise for effective removal by skimming from the surface. It is best to avoid phosphorus build-up from back stock.*

If you use phosphorus these days, use Ajax phosphor Copper (useful also in producing your phosphor bronze).



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New information about

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Just published — "Magnesium — Cerium — Zirconium Alloys," by A. J. Murphy, M.Sc., and R. J. M. Payne, B.S. Illustrated. A copy of this valuable information available on request.

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News of...

ENGINEERS COMPANIES SOCIETIES

sion at its Chicago office to serve the agricultural field of the Middle West.

The *Eastman Kodak Co.* has opened a new plastics laboratory, the first of its kind in the camera industry. It is being used to intensify its development of plastic parts for cameras, projectors and other photographic apparatus. A plastic parts museum is also being set up in the laboratory, consisting of hundreds of plastic products, photographic and otherwise, the purpose being to study "how the other fellow uses plastics." Among equipment are testing devices to measure impact, bending, hardness, stiffness and heat distortion; also injection and compression presses and casting apparatus.

A new Detroit research group has been formed, using as a nucleus the *Detroit Testing Laboratory*, 554 Bagley Ave. The purpose is to furnish Detroit industries equivalent facilities to the large motor companies. The Detroit Testing Laboratory was started on a "shoe-string" in an attic in 1903 by William P. Putnam and served in early years as a "wet-nurse" for several of Detroit's now famous factories. Douglas Dow, formerly director of commercial research, Detroit Edison Co., assumes direct management.

Lippincott & Margulies, Inc. is the new name of the New York designing firm formerly known as J. Gordon Lippincott & Co., Inc. The new member is Walter P. Margulies.

The *Marwin Co.*, maker of "C-RO" metallographic polishing compound, has moved from Caldwell, N. J., to 10604 Brunswick Ave., Silver Spring, Md.

The *Chicago Pneumatic Tool Co.* will construct a huge new plant in Utica, N. Y., this spring. It has been designed with the newest techniques in materials handling, work simplification and safety provisions.

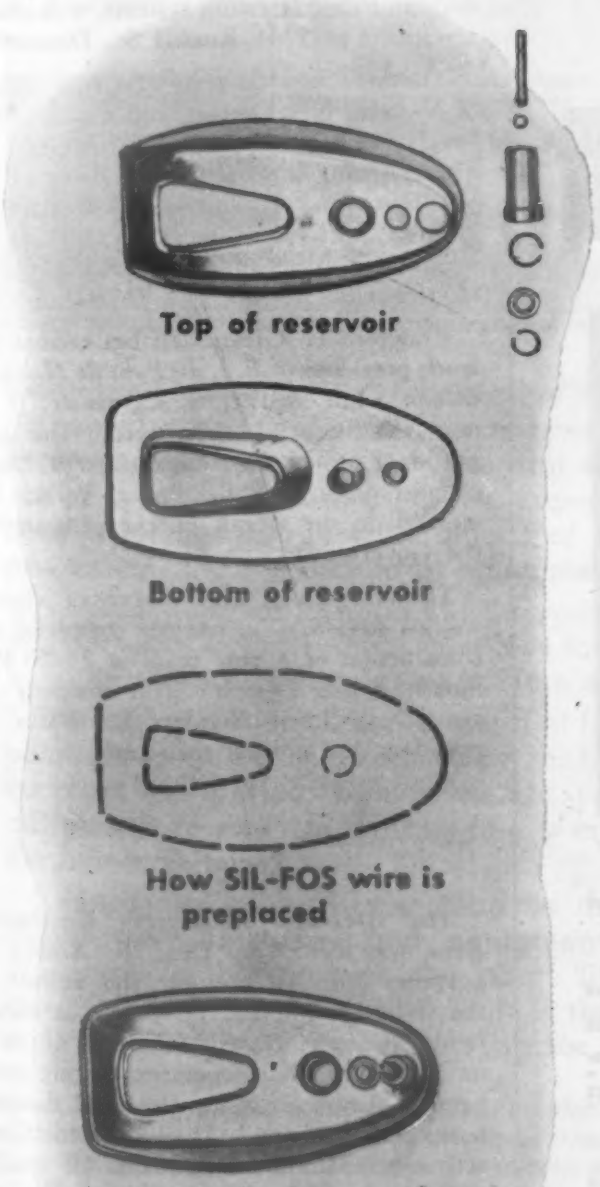
North American Philips Co. plans to introduce in the spring a completely new system of projection television known as Protelgram, featuring a 2½-in. cathode ray tube, a special optical box and a high tension power supply that will produce a 12- by 16-in. picture. Several manufacturers plan to incorporate the system into their sets. The company has a new president, P. Van den Berg, formerly vice president and general manager.

The *Nelco Tool Co., Inc.*, a pioneer in the tungsten carbide milling field, has moved from Brooklyn, N. Y., to a new plant recently purchased at 266 Center St., Manchester, Conn. The company now turns out cutting tools up to 16 in. in dia.

The *Norma-Hoffman Bearing Corp.*, Stamford, Conn., has a new president, Charles Pomeroy Collins, formerly secretary and general counsel of SKF Industries, Philadelphia.



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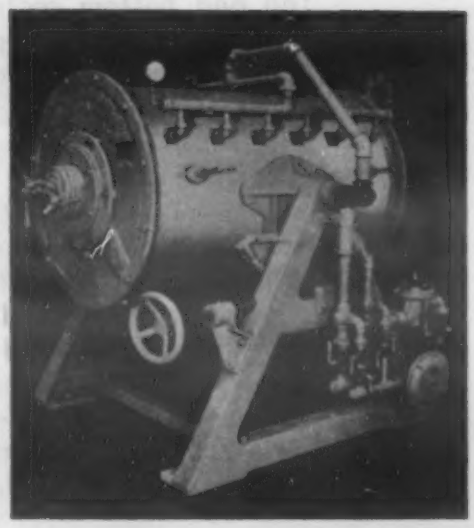
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The *General Electric X-Ray Corp.* has moved its main offices, laboratories and manufacturing plant from various locations in Chicago to 4855 W. McGeoch Ave., Milwaukee 14.

Camcar Products Co., Rockford, Ill., has completed its modern new one-story daylight plant for the manufacture of special and standard screw products.

The *Armstrong Bros. Tool Co.* is now operating in a new plant at 5200-5300 W. Armstrong Ave., Chicago 30. This ultra modern plant is of the monitor-type, one-story construction in light gray brick with stone trim and beautifully landscaped.

The *Newcomb-Detroit Co.* recently acquired the Newcomb Engineering Co., Grand Rapids, Mich., to be known as the Grand Rapids Div. The company are engineers and manufacturers of finishing systems and dust arresting systems, with offices and plant at 5741 Russell St., Detroit 11.

The *Selenium Corp. of America*, affiliate of Vickers, Inc., Detroit, and a unit of the Sperry Corp., has been voluntarily dissolved. The company is succeeded by *Vickers Electric Div., Vickers, Inc.*, 2160 E. Imperial Highway, El Segundo, Calif., maker of selenium rectifiers and self-generating photoelectric cells.

Crawford H. Greenewalt has become the tenth president of *E. I. du Pont de Nemours & Co.* while Walter S. Carpenter, Jr. is now chairman of the board. The new president joined the company in 1922 as a chemist in the Philadelphia works. He worked on the atomic energy program for the Government.

Standard Tube Co., maker of electric welded steel tubing, recently completed the construction of a new plant at 24400 Plymouth Road, Detroit. The company recently appointed Stanley L. Willis as president and general manager.

Societies

The *American Metallizing Contractors Assn.* was formed on Dec. 29. Among its purposes are: To promote the welfare of the industry, interest the public in metallizing, foster "mutual relations of trust, understanding and cooperation among members of the industry," collect and disseminate statistics, and conduct educational activities. Minimum standards of quality will be set. The new president is William Fatka, president, Metallizing, Inc., Chicago. Communications should be addressed to Walter B. Meyer, Sect.-Treas., American Metallizing Contractors Assn., 773 Brownell Ave., St. Louis 22, Mo.

The *Pittsburgh International Conference on Surface Reactions*, 1117 Wolfendale St., Pittsburgh 12, Pa., will be held at the

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Mellon Institute for Industrial Research in Pittsburgh June 7-11. Technical sessions will be held mornings and evenings, and visits to Pittsburgh research laboratories, which are working on surface reactions, in the afternoons. Scientists, engineers and educators from many parts of the world have been invited.

The *American Foundrymen's Assn.* will confer gold medals upon three outstanding foundrymen at the Foundry Congress and Show in Philadelphia May 3-7 for their contributions to the castings industry. They are: Egbert H. Ballard, Swampscott, Mass.; R. G. McElwee, Vanadium Corp. of America; and Peter E. Rentschler, Hamilton (Ohio) Foundry & Machine Co. Also, AFA President Max Kuniansky will be honored for his leadership in 1947-48. William B. Wallis, president, Pittsburgh Lectromelt Furnace Corp., has been nominated for AFA president in 1948-49.

The *Instrument Society of America* will hold its third instrument conference and exhibit at Philadelphia Convention Hall Sept. 13-17. Other societies cooperating are: the American Institute of Physics; Industrial Instruments and Regulators Committee of the American Society of Mechanical Engineers, and the Instruments and Measurements Committee of the American Institute of Electrical Engineers.

The *Society of the Plastics Industry* will hold its annual meeting in Atlantic City May 20 and 21. It will meet separately for the first time from the annual National Plastics Exposition, Sept. 27-Oct. 2 in Grand Central Palace, New York. The West Coast section, Society of the Plastics Industry, will hold its annual conference and exhibit at Santa Barbara, Calif., Mar. 28-31. The merchandising exhibit will demonstrate the most successful procedure in originating, designing, advertising and marketing typical plastic products.

The *National Castings Council* has been organized by eight foundry associations to provide a medium for co-operative action on matters of mutual interest. Member societies are: American Foundrymen's Assn., Foundry Equipment Mfgrs. Assn., Foundry Supply Mfgrs. Assn., Gray Iron Founders' Society, Malleable Founders' Society, National Founders' Assn., Non-Ferrous Founders' Society, Inc. and Steel Founders' Society of America. The president of the new council is Howard A. Stockwell, sec., Barbour Stockwell Co., Cambridge, Mass.

The third *Southern Machinery & Metals Exposition, Inc.* will be held at the Municipal Auditorium, Atlanta, Ga. Apr. 5-8. Plant tours of manufacturing plants in the Atlanta district will be held concurrently

(Continued on page 158)

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This fast, scientific method for measuring resistance to surface abrasion reveals the pertinent facts in a matter of minutes. Eliminates time-consuming, expensive performance tests. Used by hundreds of manufacturers for determining surface wearing qualities of paint, lacquer, plastics, leather, rubber, paper, metals, etc.

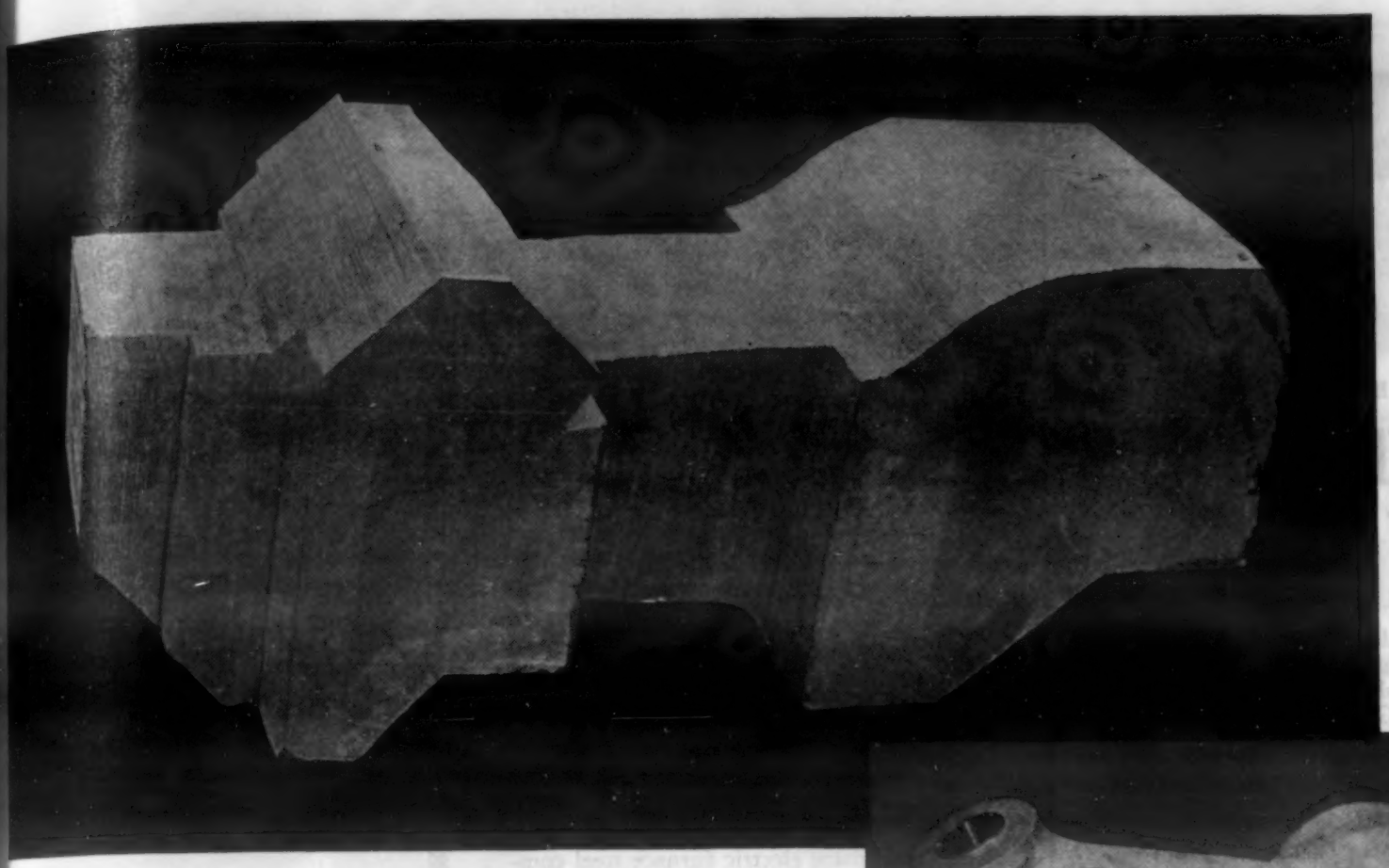


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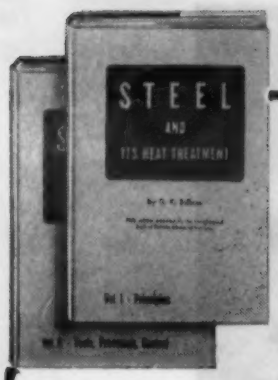
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STEEL AND ITS HEAT TREATMENT

VOLUMES I AND II

Fifth Edition prepared by the Metallurgical Staff of Battelle Memorial Institute, directed by W. H. Gillett, Chief Technical Adviser

This new edition of a well-known work by an authority on steel and its heat treatment contains the latest information in this important field.

Volume I explains the principles behind heat treatment of both carbon and alloy steel, and stresses the definitions and terminology necessary for understanding the subject. The uses and limitations of tests to evaluate suitability of steel for heat treatment and to determine proper engineering uses for heat-treated products are thoroughly discussed.

Volume II shows the practical applications of the principles covered in Volume I. The results of the misapplication of these principles are also shown by illustrations and explanations. Furnaces, quenching media, and other tools are discussed and photographs shown of actual installations in operation. Methods of preventing cracking and distortion, preparation of steel for machining, the relation of heat treatment to welding, and heat treatment of steel castings, malleable iron, and cast iron are among the many topics covered. The important role played by experience and personal judgment is recognized and emphasized in a chapter devoted to the "human" element.

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with the exposition. The exhibit will contain equipment, machinery and tools in actual operation. Ferrous and nonferrous tubing, bars, sheet, castings and forgings will be shown.

The *Carnegie Institute of Technology* has broken ground for its new synchro-cyclotron on the site of the former KDKA transmitting station at Saxonburg, Pa., on a 60-acre site. Here there will be plenty of room for expansion of nuclear research facilities. The cyclotron should be in operation early in 1950. It will produce 350 million electron volts, instead of 250 million, as originally announced, the step-up being due to improvements in design of its 1000-ton electromagnet.

John B. Caine, metallurgist, Sawbrook Steel Castings Co., Lockland, Ohio, has been elected chairman, electric furnace steel committee, *American Institute of Mining & Metallurgical Engineers.* He will preside at the sixth annual furnace steel conference at Pittsburgh, Dec. 2-4, 1948.

The 1948 Washington award has been tendered this year by the five sponsoring societies to Senator Ralph E. Flanders, Vermont, himself a mechanical engineer. It is awarded annually to an outstanding engineer who has ably served human needs. The sponsoring organizations are: The *Western Society of Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers,* and *American Institute of Mining & Metallurgical Engineers.*

R. J. S. Pigott, Pittsburgh, is the 1948 president of the *Society of Automotive Engineers.* He is chief engineer, Gulf Research & Development Co. Mr. Pigott has been awarded more than 30 patents on devices used in hydraulic engineering, heating, oil production, and other fields, and has published 40 technical papers on power station design, fluid flow, instruments, etc.

The library of the *Carnegie Institute of Technology* has received the major portion of the issues of 12 different Japanese scientific research publications that appeared during the recent war. Half are printed in Japanese; the others in English.

The dean of *New York University's College of Engineering* has recommended a somewhat radical change in curricula in line with modern thought on engineering education. A general four-year course would be established which substantially all engineering students would take. It would be uniform for the first three years, consisting of all the basic sciences and fundamental engineering subjects now offered, but would add courses in history, public affairs and economics. The highly specialized subjects now on the increase in several sophomore and junior year curricula would be omitted. The senior year would have a considerable number of electives.

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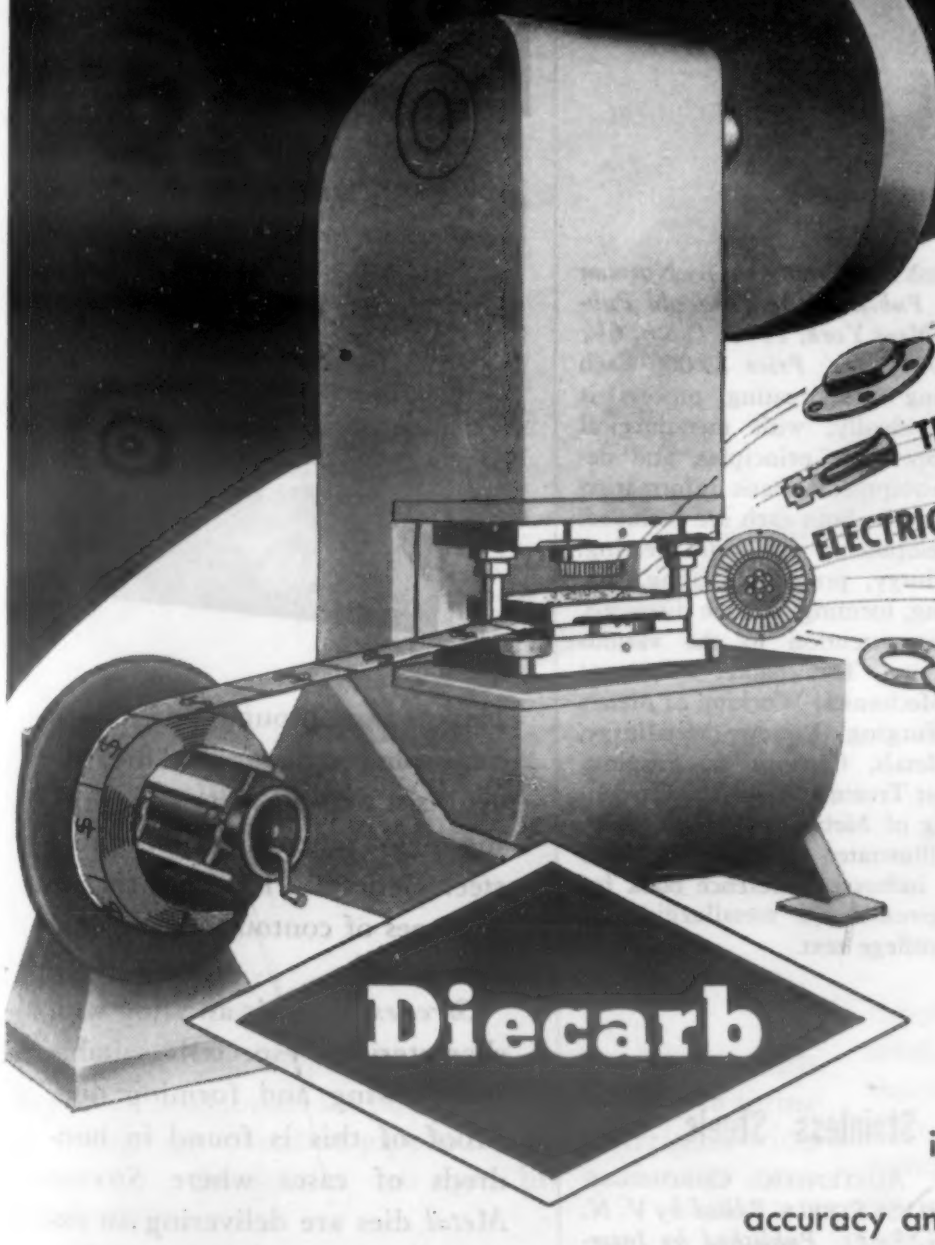
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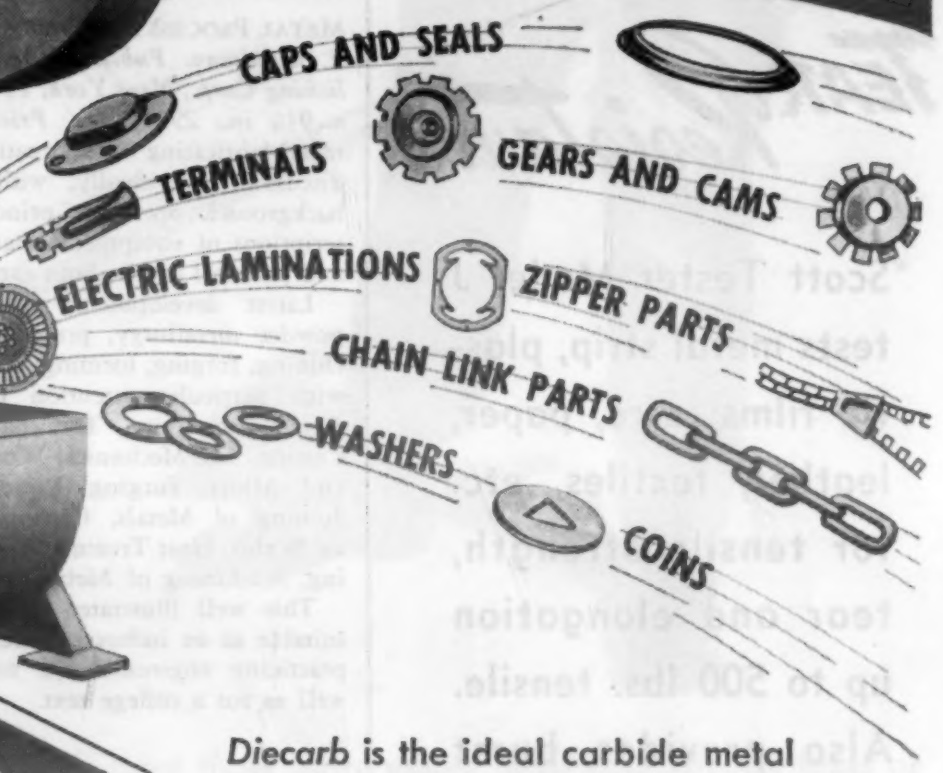
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BOOK REVIEWS

Metal Process Engineering

METAL PROCESS ENGINEERING. *By Norman E. Woldman. Published by Reinhold Publishing Corp., New York, 1948. Cloth, 6¼ x 9¼ in., 291 pages. Price $5.00.* Each metal-fabricating and treating process is discussed individually, with metallurgical background, operating principles, and descriptions of equipment. Basic information and practical detail about each are included.

Latest developments in heat treating, powder metallurgy, precision casting, machining, forging, forming, etc. are discussed, with particular attention to the various metals and alloys. The chapter titles are: Casting, The Mechanical Working of Metals and Alloys, Forging, Powder Metallurgy, Joining of Metals, Castings vs. Forgings vs. Welds, Heat Treatment, Surface Hardening, Machining of Metals, and Tool Steels.

This well illustrated volume should be suitable as an industrial reference book for practicing engineers and metallurgists, as well as for a college text.

Forming of Stainless Steels

FORMING OF AUSTENITIC CHROMIUM-NICKEL STAINLESS STEELS. *Edited by V. N. Krivobok & G. Sachs. Published by International Nickel Co., Inc., New York, 1947. Cloth, 8¾ x 11¼ in., 309 pages. Price $4.00. (The second printing will not be available until Apr. 15, 1948.)* The principal stainless steel producers and fabricators cooperated with the International Nickel Co., Inc. and provided full information not hitherto exchanged, making possible this unusual technical and practical volume. A detailed description of the modern forming procedures as applied to chromium-nickel stainless steels in various forms is presented.

The topics discussed are: Mechanical Properties of Chromium-Nickel Stainless Steels; Forming Characteristics of Austenitic Stainless Steels; Processing After Forming; Design, Layout and Preparation of Blanks; Equipment, Tools and Lubricants; Bending and Straight Flanging; The Forming of Curved Sections and Tubing; Forming of Contoured-Flanged Parts; Deep Drawing of Cup-Shaped, Box-Shaped and Related Parts; Double-Action Die Forming of Deep- and Shallow-Recessed Parts; Forming of

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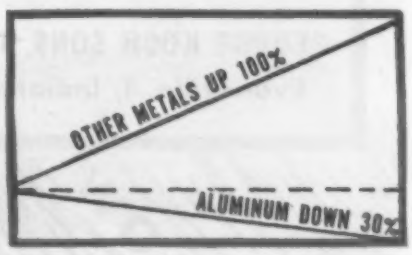
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More than 25 individuals and 50 companies have been of assistance in this undertaking. It is well illustrated.

The Heat Treatment of Steel

STEEL AND ITS HEAT TREATMENT—FIFTH EDITION, VOL. I—PRINCIPLES; VOL. II—TOOLS, PROCESSES, CONTROL. *By D. K. Bullens and the Metallurgical Staff of Battelle Memorial Institute. Published by John Wiley & Sons, Inc., New York, 1948. Cloth, 6¼ x 9¼ in., 489 pages and 293 pages, respectively. Price $6.00 and $4.00, respectively.* Theories have been advanced only so far as thought necessary for a clear understanding of principles; experimentally established facts are considered more important. Information of practical utility is presented and the limitations as well as the possibilities of present methods, equipment and tests are shown.

Volume I deals with the definitions, terminology, and fundamental concepts necessary for discussion of heat treatment; with the limitations and uses of tests applied to evaluate suitability of steel for heat treatment, and suitability of the heat treated product for engineering use; and with the principles underlying the various types of heat treatment, whether of carbon or alloy steel.

Volume II deals with applications of the principles and with the tools of heat treatment, such as furnaces, devices for local heating, salt baths, controlled atmospheres, cyaniding, carburizing and nitriding; quenching media; prevention of cracking and distortion; the processes used to put steel in proper condition for machining; the relation of heat treatment to welding; and the heat treatment of steel castings, malleable iron and cast iron. It is aimed to cover the practical application of the principles described in Volume I.

Other New Books

ELECTRICAL RESISTANCE WELDING—A BIBLIOGRAPHY OF THE LITERATURE FROM JAN. 1936 TO JUNE 1947. *By Harold S. Card. Published by Harold S. Card, 850 Euclid Ave., Cleveland 14, Ohio. Paper, 8½ x 11 in., 22 pages. Price $1.00.* Data on 646 articles published in 49 technical and industrial magazines during the above period are given; many of these titles are accompanied by synopses. The entire list has been indexed according to subject matter. Current standards publications and books are included.

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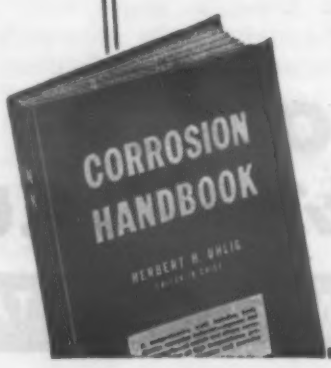
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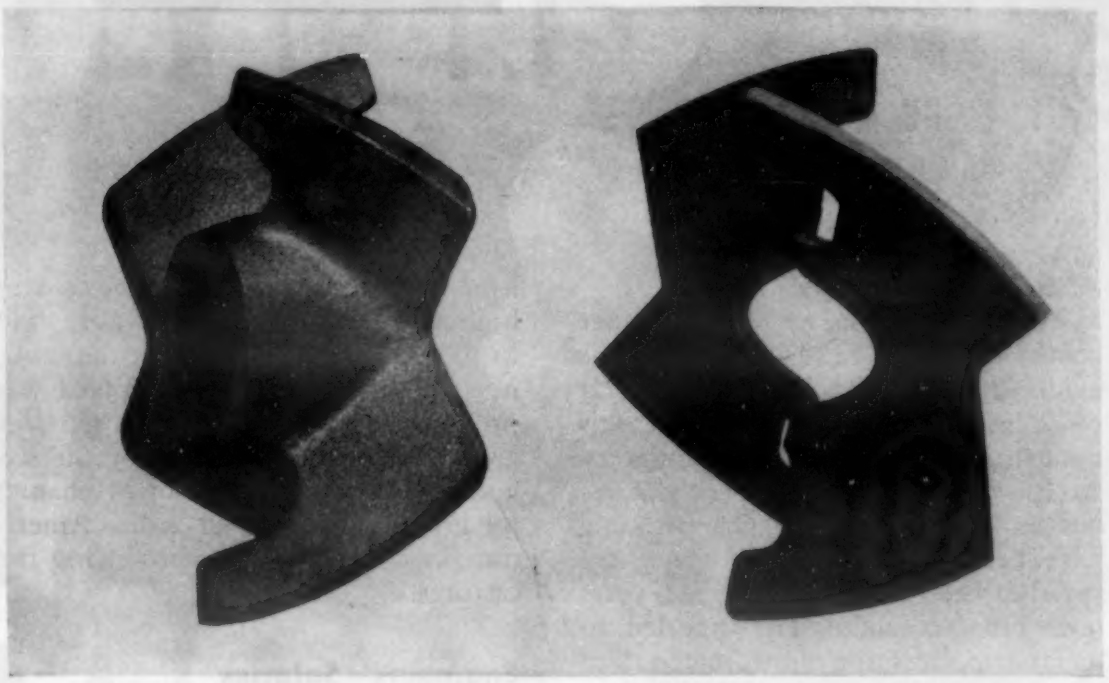


Fig. 1. Left: The former agitator blade unit. Right: The pressed steel unit, now used.

IN the manufacture of farm implements, we are searching constantly for production methods that will reduce costs and yet maintain high quality and wherever possible improve the strength and performance of our implements. One outstanding example of cost reduction is illustrated in the recent conversion to welded design for the agitator shafts of our lime and fertilizer spreaders.

A simple change in the design of one part for welded assembly has cut the shop costs of these agitator shafts from $6.96 to $4.03, representing a saving of 42% on these units alone. In addition to these cost savings, we have improved the performance of our product.

Originally, the agitator blade units were made from individual parts of conventional construction, each of which required several machining operations. The center hole had to be machined and a radial hole drilled and tapped. A set screw was then inserted for anchoring the blade unit to the shaft. With the welded design, the pressed alloy steel agitator blade units are slipped over the shaft and permanently assembled in place by tack welding them to the shaft. Hence, with this construction, the blade units become an integral part of the shaft, and this eliminates any possibility of the blades working loose in service. The welding is done with 3/16" "Fleetweld 37" electrode and Lincoln "Shield-Arc" welders.

The blade units are welded to the hub of the blades as shown in Fig. 2. This simply requires a tack weld between the bars and the hub of the blade unit. This design, made practical by welding, increases the thoroughness of the agitation, further improving the performance of our spreader. Attaching sweep bars with our former construction would have been a difficult and costly operation.

The same principles of welded construction used in fabrication of our agitator shaft assemblies, are used also in building the center bearing support plate by welding the center bearing to a sheared steel plate as shown in Fig. 2. The main framework and body of the spreader (Fig. 3) are also of arc welded steel construction.

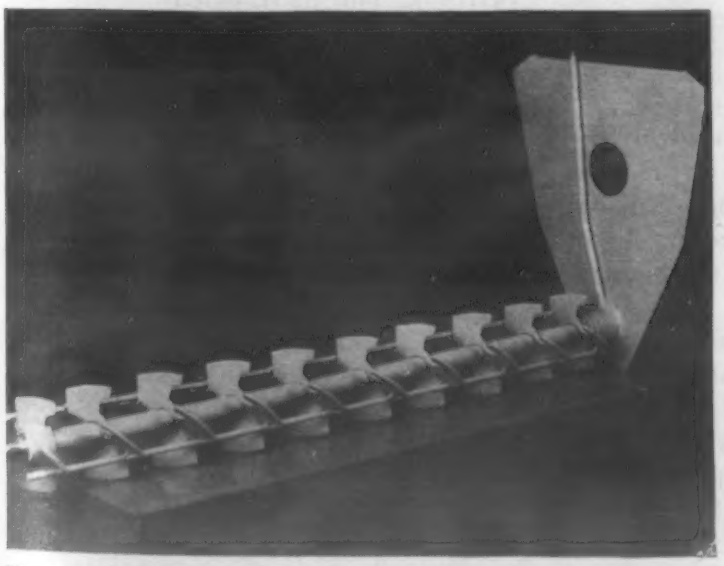


Fig. 2. Agitator shaft assembly showing welded blade units and sweep bars. All welded center plate is shown at right.

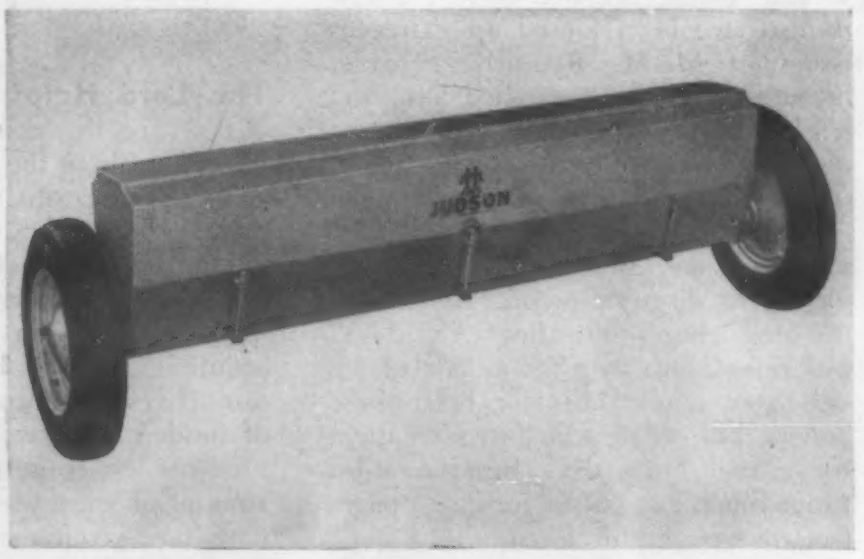


Fig. 3. All welded Judson lime and fertilizer spreader.

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The Last WORD

by T. C. DU MOND

A Boon to Wimpy

Those of you who follow newspaper comic strips are aware of Wimpy's avidness as regards hamburgers. It must be that many humans have this same eagerness for succulent 'burgers. At least the customers of Lee's Hamburger Stand down N'Orleans way have been less than happy about the speed of Lee's service. For several years now Lee has plaintively appealed to metal suppliers for some material to use on his grill which would not lose its heating efficiency through the staining induced by blood, grease, onions, etc. Being persistent has been rewarding to Lee, for now he has a shiny new grill which promises to solve his problem. It's made of a new clad metal—stainless clad copper. This problem was solved by a Tinkers-to-Evans-to-Chance double play involving Alloys Development Corp., a large steel company, and American Cladmetals Co.

Type Lice Prevalent

Anyone who has spent time in a print shop has more than a passing acquaintanceship with type lice. These insects are somewhat akin to the gremlins blamed for causing mishaps to wartime aviators. Anyhow, whether we can blame the lice or not, a few things have been loused up in recent issues of M&M. Recently a reader in Seminole, Okla., searched long and hard to track down an etchant referred to in one of our captions. He plaintively asked us for information on "pecial." The type lice changed an "i" to an "e" and an "r" to an "i" completely to disguise picral. In another instance aluminum alloy Alclad 3S was referred to in print as Alclad 35. We have good alibis for both these boners, but we're going to save them for a real rainy day. Besides, alibis prove much less satisfactory than pages free of typographical errors.

A Happy Ending

Recently—November, to be exact—we ran an article telling how a batch of inferior castings was reclaimed by taking advantage of the fact that cast iron "grows" upon being subjected to high temperatures. What wasn't told in the article is the fact that the hardness needed in the parts involved was provided later by making the parts of grade C Meehanite. A tip of the hat goes to "Cec" Herington of Meehanite for giving us the sequel and to American Brake Shoe Co. for producing the castings.

Engineers' Salaries

In these days of high wages for such difficult jobs as those of "disc jockeys" and radio masters of ceremonies, it is little wonder that engineering does not hold too much fascination for our younger men. It takes at least four years to study engineering, but a few weeks at a juke box makes a "disc jockey." These thoughts arise from the results of a survey carried on by the New York University, School of Engineering. The survey sought to find "first job conditions" in today's engineering fields. Average salaries on first jobs showed low to be $206 per month in administrative, and high $257 for electrical engineering. One highly recommended chemical engineer wound up selling Oriental rugs, while a graduate electrical engineer is selling candy —wholesale—for $400 a month.

The Lord Helps Those

Few are the people today who do not know about the severity of the iron and steel scrap situation. One company is doing more about the problem than talking. American Brake Shoe Co. recently took positive action by searching for scrap other than that normally acquired. In two forge plants, where test drives were conducted, 200 tons of hidden scrap were unearthed. Figured at a conservative price, this amount of scrap was worth $8,000 and may have given a new lease on life to some foundry or steel mill furnace. Look in your back yard. Do you have any obsolete dies, machinery or equipment; pieces of rail; flasks (no, not the glass ones) or tote boxes? If you have, you know what to do.

Just Another Complication

Encroachers! And in one of the engineer's most firmly held domains. When the American Standards Association decided that the term "pounds per square inch" should be represented by the abbreviation "psi," the editors of M&M registered a mild dissent by pointing out that psi was also a letter in the Greek alphabet, and we have deviated slightly by using "psi." as our style. After all, the Greeks had a letter for it long before we did.

Now comes a new dizzying complication. Several psychologists, apparently bloated with a diet of alphabet soup, have decided to combine the idea of "extrasensory perception," conveniently shortened to ESP, with that of "psychokinesis," whittled down to PK, and the result comes out—yes, you've guessed it—psi (no period).

This New Look in psi, it seems, means that the mind appears to influence physical objects. Whether those dice will turn up that point or a seven is a matter of mental control, though personally we have always suspected application of rosin, or switched dice, or other purely physical means of manipulation. There certainly are some strong-minded people in the world.

Well, all is not lost. We'll keep our psi., and let the psychologists have their psi, sans the period. If this psychological psi, which seems to be a sort of high-brow whammy, really works, we can even see a ray of sunshine through the clouds of our loss.

M&M Achievement Award

Many of our readers have been asking about the next MATERIALS & METHODS Achievement Award Competition. For their benefit, there will be an announcement in our April issue telling all about it. In the meantime, start gathering data on the things you have done in your plant of which you are particularly proud.

Another Member of the Family

We are guilty of a terrible oversight. In last month's issue we failed to announce an addition to the M&M family of editors. The latest arrival is Stephen (Steve) Smoke who hails from Allentown. Steve was born in McKeesport, Pa. Therefore, we can't say he comes clean from Pittsburgh. For the last nine years, interrupted only by college (Lehigh) and Uncle Sam (Army), Steve served Bethlehem Steel. At Lehigh, Steve was quite a quarterback. Now he's pitching words instead of footballs. You can see the Smoke in his first pitch on page 86 of this issue.